ISO 10303
STEP APPLICATION HANDBOOK
VERSION 2

CONTRACT NO.: N00140-01-D-L614
STRATEGIC SOURCING TECHNOLOGIES (SST) PROGRAM
21 DECEMBER 2001

PREPARED FOR:

DEFENSE LOGISTICS AGENCY
FORT BELVOIR, VA 22060-6221
In cooperation with
Naval Sea Systems Command
Washington, DC 20376

PREPARED BY:

SCRA®

5300 INTERNATIONAL BOULEVARD.
NORTH CHARLESTON, SC 29418

Foreword

The development and implementation of the STandard for the Exchange of Product model data (STEP) is dynamic and on-going. "STEP" is actually a series of standards, developed by experts worldwide, under the auspices of ISO Technical Committee (TC) 184, Sub-Committee (SC) 4. A handbook such as the following represents a “snap shot” of the information as it exists at this point in time.

This handbook, which updates the STEP Application Handbook published in June 2000 (See Document 18, Appendix A), concentrates on identifying the application domains being covered by STEP development, identifying commercially available tools for using STEP, and providing guidance on using the STEP technology that is currently available. It updates those STEP Application Protocols (AP’s) that have achieved International Standard (IS) status, those AP’s that are currently active (or about to be activated), those AP’s that are currently implemented and have commercially available translators, and those AP’s that have been or are currently being piloted, prototyped, or proved-out.

This handbook is intended as an updated collection of information on the current state of STEP and it’s current usability. It is intended to provide information of value to engineering users with a need to exchange product data with customers and/or suppliers.

An attempt has been made to distinguish between what is “real” now and what is theoretically possible in the future and to identify some of the current obstacles to achieving the ultimate goal of STEP. (i.e., to provide a complete, unambiguous, neutral computer-interpretable standard for representing product data throughout the lifecycle of the product)

Acknowledgements

Much information has been extracted from the many STEP related Web Sites. An attempt has been made to identify the source of most of the information, but in many instances overlapping information came from multiple sources. The information in the tables is a compilation of information from many sources. Numerous web sites are listed in the body of the handbook and in the Appendix B along with the documents in Appendix A. Many of the references were the sources of much of this information; some of them are simply listed for further reading beyond the intent of this document.

Particularly helpful were the ISO Web Site, the PDES, Inc. Public Web Site, the SC4 Web Site at NIST, the Theorem Solutions Web Site, the UK Council for Electronic Business (UKCEB) Web Site, the Naval Surface Warfare Center, Carderock Division and USPRO.

Abstract/Executive Summary

Organizations can not do e-commerce if the technical drawings are “in the mail”. Digital technical data standards are a cornerstone of e-business. If we are going to do “commerce at light speed”, the use of neutral digital technical data standards is one of the requirements. The STandard for the Exchange of Product model data (STEP) is an International Organization for Standardization (ISO) product model data exchange standard (identified as ISO 10303) that is designed to meet this need.

This handbook is intended as a collection of information on the current state of STEP and it’s current usability. "STEP" is actually a series of standards, developed by experts worldwide, under the auspices of ISO TC184/SC4. It is intended to provide information of value to engineering users with a need to exchange product data with customers and/or suppliers.

The handbook concentrates on identifying the application domains being covered by STEP development, identifying commercially available tools for using STEP, providing guidance on using the STEP technology that is currently available, and providing sources of additional information.

This handbook updates the STEP Application Handbook previously published in June 2000. It presents a brief introduction to STEP along with an indication of how the ISO Standardization Process works relative to STEP. The reader is made aware of the current status of STEP development with emphasis on those parts of STEP that have achieved International Standard (IS) status and those parts that are currently being developed. The scope of each STEP Application Protocol (AP) is presented to indicate what is and what isn't addressed in the AP's. This information is presented so that the engineering user is able to see the depth of coverage of the AP's and to identify those STEP AP's and their associated conformance classes that best will meet the user's product data exchange (PDE) requirements. The section on STEP Application Suites has been expanded to illustrate the integration/interaction of STEP Application Protocols in a variety of application domains. This has become more relevant as a greater number of AP have achieved IS status.

There is some discussion on some development and implementation approaches that have started to appear in the last two years. These approaches are intended to expedite the development process and to enable implementation and use of STEP for product data exchange in a web-based environment.

A table is provided showing commercially available PDE translators from the major CAD/CAM vendors. This table includes STEP translators as well as direct translators and translators that use other PDE formats. This table has not changed much since June 2000. It is noted that there is a trend toward translation service bureaus and an increased number of these services.

At this point, commercially available implementation of STEP translators are still pretty much limited to several conformance classes of AP203 - Configuration Controlled Design and

two conformance classes of AP214 - Core Data for Automotive Mechanical Design Processes which are roughly equivalent to AP203. Over the past two years, these products have improved significantly. Many have added modules for supplementary capabilities, and almost all have added (or improved) “healing” capabilities. Reference is made to major companies who have put this current STEP capability into production.

Despite the limited coverage of STEP AP's in the commercial marketplace, there are (and have been) numerous pilot, prototype and proof-of-concept implementations of the many STEP Application Protocols as they have been evolving through the stages of ISO standardization. Many of these pilot projects are cited in the handbook to emphasize the successful demonstration of the power and robustness of the evolving STEP standards. Some of the major companies have implemented (or are implementing) in-house implementations of STEP Application Protocols.

An attempt has been made to distinguish between what is “real” now and what is theoretically possible (& achievable) in the future and to identify some of the current obstacles to achieving the ultimate goal of STEP. (i.e., to provide a complete, unambiguous, neutral computer-interpretable standard for representing product data throughout the lifecycle of the product.)

Some guidance is provided for the engineering user in using the currently available STEP capability. Many obstacles have been overcome and many lessons have been learned in bringing this "first phase" of STEP implementation into production. Some hints, guidelines and checklists are provided and referenced to assist in using the currently available STEP technology.

The STEP-related product that is commercially available to the engineering user community is essentially AP203 and its "look alike" AP214 cc 1&2 (i.e., geometry (wireframe, surfaces & solids) with some configuration management data). What is available is really very good --- good enough to be in production at Boeing, Lockheed Martin, General Motors, General Electric, Pratt & Whitney, Rolls Royce, Electric Boat, Northrop Grumman and other large companies and government facilities. But STEP presents a much more powerful and robust technology beyond that currently implemented and this is being demonstrated in numerous Research & Development environments.

STEP is still evolving and is now at a point in its evolution when a significant number of Application Protocols have achieved International Standard status. There are now 12 STEP Application Protocols that are International Standards and others that are steadily moving toward that status. STEP is and will be more than AP203. The user community needs to look more closely at the AP's and their associated conformance classes to determine what components/parts of STEP best meet their requirements. In order to realize the "full" power of STEP, the user community has to drive vendor implementation of the AP conformance classes that meet their business objectives. In order for this to happen, strong business cases need to be developed in order to get the CAD/CAM/CAE Vendors on board.

Table of Contents

Table of Figures

List of Acronyms

2D	Two Dimensional
3D	Three Dimensional
ABS	American Bureau of Shipping
ACORN	Advanced Control Network
AEA	Aerospace Engine Alliance - AP203/PDM Schema
AEC	Architecture, Engineering, Construction
AES	Atlantec Enterprise Solutions
AFNOR	Association Française de NORmalisation (French Standards Organization)
AIAG	Automotive Industries Action Group
ANAD	ANniston Army Depot
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ATI	Advanced Technology Institute
ATP	Advanced Technology Program (NIST)
AWS	Advanced Weapon System (AP203/AP202)
B-Rep	Boundary Representation
Brite EuRam	A research program on raw materials and advanced materials
BSI	British Standards Institute
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CALS	Computer Aided Logistics Support
	Computer-Aided Acquisition & Logistics Support
	Continuous Acquisition and Life-cycle Support
	Commerce At Light Speed
CALYPSO	Computational Fluid Dynamics in the Ship Design Process
CAM	Computer Aided Manufacturing
CAMP	Cleveland Advanced Manufacturing Partnership
CAPP	Computer Aided Process Planning
CAx	Generic name for CAD/CAM/CAE
CCITT	Consultative Committee International for Telegraphy &Telephony (ISO)
CEB	Containment Early Binding
CEC	Center for Electronic Commerce (at ERIM)
CIM	Computer Integrated Manufacturing
CIMSTEEL	Computer Integrated Manufacture for constructional STEELwork - AP230
CLDATA	Cutter Location Data
CM	Configuration Management
CMM	Coordinate Measuring Machine
CNC	Computerized Numerical Control
COM	CATIA Object Manager
COTS	Commercial Off-The-Shelf
CSG	Constructive Solid Geometry
DARPA	Defense Advanced Research Program Agency
DDE	Data Definition Exchange
DIN	Deutsches Institut für Normung (German Standards Organization)

DL	Data List
DLA	Defense Logistics Agency
DoD	Department of Defense
DXF	Data eXchange Format (Public Domain from Autodesk)
DTD	Document Type Definition
DWG	DraWinG format (Public Domain from Autodesk)
EADS	European Aerospace, Defence, and Space company
ECRC	Electronic Commerce Resource Center
EDIF	Electronic Design Interchange Format (ANSI/EIA)
EDIMAR	Electronic Data Interchange for the European Maritime Industry
EDM	Electrical Discharge Machining
EIA	Electronic Industries Association
EMSA	European Marine STEP Association
ERIM	Environmental Research Institute of Michigan
EPISTLE	European Process Industries STEP Technical Liaison Executive (AP221)
ESPRIT	European Commission - Specific RTD PRogramme in the field of Information Technologies
ESTEP	Evolution of STEP
FEA	Finite Element Analysis
FEM	Finite Element Modeling
FunSTEP	Furniture STEP
GALIA	Groupement pour l'Amelioration des Liaisons dans l'Industrie Automoblie (French)
GDLS	General Dynamics Land Systems
GM	General Motors
GOSET	Operational Group for the Standard for Exchange and Transfer (French)
GSCAD	Global Shipworks CAD (an Intergraph CAD System)
GUI	Graphical User Interface
IAV	Interim Armored Vehicle
IDL	Indentured Data List
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IGES	Initial Graphics Exchange Specification (ANSI/ASME)
IL	Index List
IMS	Integrated Manufacturing Systems
INCOSE	International Council On System Engineering
IPC	Institute for interconnecting and Packaging electronic Circuits (ANSI)
IPO	IGES/PDES Organization
ISAP	International STEP Automotive Project
ISDP	Integrated Ship Design & Production (an Intergraph Suite of Products)
ISE	Integrated Shipbuilding Environment
ISEC	Integrated Shipbuilding Environment Consortium
ISO	International Organisation for Standardisation ⇒ AWI - Approved Work Item ⇒ CD - Committee Draft ⇒ DIS - Draft International Standard

⇒ FDIS - Final Draft International Standard
⇒ IS - International Standard
⇒ JWG - Joint Working Group
⇒ NWI - New Work Item
⇒ PWI - Preliminary Work Item
⇒ SC - Sub Committee
⇒ TC - Technical Committee
⇒ WG - Working Group

ITI	International TechneGroup, Inc.
JAMA	Japanese Automotive Manufacturers Association
JECALS	Japan EC/CALS
JEDMICS	Joint Engineering Data Management Information & Control System
JMSA	Japan Marine Standards Association
JSTEP	Japan STEP promotion center
KCS	Kockums Computer Systems
KRISO	Korean Research Institute of Ships and Ocean engineering
KS-STEP	Korean Ship – STEP
KPSI	Kvaerner Philadelphia Shipbuilding, Inc.
LEAPS	Leading Edge Advanced Prototyping for Ships
LM-TAS	Lockheed Martin - Tactical Aircraft Systems
MariSTEP	MariTech STandard for Product Model Exchange
MATINF	MATerial INFormation
MiTS	Maritime Information Technology Standard (IEC TC80/WG6)
MOF	Meta-Object Facility
MoD	Ministry of Defence
MOSys	Models for Operational reliability, integrity, and availability analysis of ship machinery Systems
MOU	Memorandum of Understanding
NAC	National Automotive Council
NASA	National Aeronautics and Space Administration
NASSCO	NAtional Steel and Shipbuilding COmpany
NAVSEA	NAVal SEA systems command
NC	Numerical Control
NextGRADE	Next Generation Revolutionary Analysis and Design Environment (NASA-Goddard Space Flight Center)
NIDDESC	Navy/Industry Digital Data Exchange Standards Committee
NIST	National Institute of Standards and Technology
NSRP	National Shipbuilding Research Program
N-STEP	NAC-STEP Enabled Production of components
NSWC	Naval Surface Warfare Center
NURBS	Non-Uniform Rational B-Splines
NWI	New Work Items
OASIS	Organization for the Advancement of Structured Information Standards
ODM	On Demand Manufacturing
OL	Other List
OMG	Object Management Group

OSEB	Object Serialization Early Binding
PAS-C	PDES Application protocol Suite for Composites
PDE	Product Data Exchange
PDES	Product Data Exchange using STEP
PDES, Inc.	United States/United Kingdom Consortium for Accelerating the Development and Implementation of STEP
PDM	Product Data Management
PDS	Product Data Set
PdXi	Process data eXchange Institute (AP231)
P&ID	Piping and Instrumentation Diagrams
PIEBASE	Process Industry Executive for achieving Business Advantage using Standards for data Exchange (AP221, AP227, AP231)
PIPPIN	Pilot Implementation of Process Plant Lifecycle Data Exchange Conforming to STEP - AP221
PISTEP	Process Industries STEP - AP221 & AP227
PL	Parts List
PLCS	Product Life Cycle Support
PLIB	Parts LIBrary
PLSSPD	Parts Library and STEP for Shipbuilding Product Data
PM	Product Management
POSC	Petrotechnical Open Software Corporation
POSC/Caesar	Petrotechnical Open Software Corporation & Caesar Systems, Ltd
PreAMP	Pre-Competitive Advanced Manufacturing Program
ProSTEP	The Centre for STEP in Germany
R&D	Research and Development
RAMP	Rapid Acquisition of Manufactured Parts ⇒ DCVE - Data Conversion & Verification Environment ⇒ GAPP - Generative Assembly Process Planning ⇒ PCA - Printed Circuit Assembly ⇒ PCB - Printed Circuit Board STEPPlan - STEP process Planner ⇒ STEPTrans - STEP Translator ⇒ STEPValidator - STEP Validator
SASIG	STEP Automotive Special Interest Group (AIAG, GALIA, VDA, JAMA)
SC	Sub-Committee
SE	System Engineering
SEASPRITE	Software architectures for ship product data integration and exchange
SEDRES	System Engineering Representation and Exchange Standardization
SCRA	South Carolina Research Authority
SEDS	SC4 Enhancement and Discrepancy System
SET	Standard d'Exchange et de Transfert (French) (AFNOR)
SGML	Standard Generalized Mark-up Language
SIS	Stereolithography Interface Specification (Public Domain from 3D Systems, Inc.)
SMS	STEP Manufacturing Suite
SOAP	STEP On A Page, **or** Simple Object Access Protocol (XML)

SOLIS	SC4 On-Line Information System
SPI-NL	Standard for Plant Information in the NetherLands
STAMP	Supply-chain Technologies for Affordable Missile Products - AP232/STEP PDM Schema
STL	Stereolithography
STEP	STandard for the Exchange of Product model data (ISO) ⇒ AAM - Application Activity Model ⇒ AIC - Application Interpreted Construct ⇒ AIM - Application Interpreted Model ⇒ AM - Application Module ⇒ AO - Application Object ⇒ AP - Application Protocol ⇒ AR - Application Resource ⇒ ARM - Application Resource Model ⇒ ATS - Abstract Test Suite ⇒ CC - Conformance Class ⇒ IR - Integrated Resource ⇒ SDAI - Standard Data Access Interface ⇒ UoF - Unit of Functionality
STEPwise	STEP web integrated supplier exchange pilot
STIR	STEP TDP Interoperability Readiness pilot
TACOM	Tank automotive and Armament COMmand
TAG	Technical Advisory Group
TC	Technical Committee
TDP	Technical Data Package
TIGER	Team Integrated-Electronic Response
UML	Unified Modeling Language
UoF	Unit of Functionality
USPro	U. S. Product data association
UK	United Kingdom
UKCEB	UK Council for Electronic Business
UKRAMP	United Kingdom RAMP
VAST	Validating Advanced Supply-chain Technology
VDA-IS	Verband der Automobilindustrie - German Standard to exchange 2D CAD Geometry & dimensions (DIN)
VDA-FS	Verband der Automobilindustrie - German Standard to exchange Surface Data (DIN)
VHDL	Very High Speed Integrated Circuit (VHSIC) Hardware Description Language (ANSI/IEEE)
W3C	World Wide Web Consortium
XMI	XML Metadata Interchange
XML	eXtensible Markup Language
XSL	eXtensible Stylesheet Language
XSLT	eXtensible Stylesheet Language Transformations

Proprietary Names of Vendors and Products

Product/Vendor	Descripton
ACIS	Geometric Modeling Kernel supporting 3D surfaces and BREP solids
AutoCAD	A CAD system developed and marketed by Autodesk
Autodesk	A CAD/CAM system developer and vendor - Develops and markets AutoCAD and Mechanical Desktop
Bentley	A Company that develops and markets CAD/CAM Software
Board Station	A CAE system for Printed Circuit Board (PCB) layout design developed and marketed by Mentorgraphics
Bravo	A CAD system developed by Applicon (now part of UGSolutions)
CADDS 4X/CADDS5	CAD systems developed by Computervision
Cadence	An Electrical/Electronic CAE System Vendor
CADKEY	A CAD system developed and marketed by CADKEY Corporation
Camand Mutax	A CAM system (formerly CAMAX) developed and marketed by SDRC
CATIA	A CAD system developed and marketed by Dassault Systemes & IBM
Computervision	A company, now, within Parametric Technology Corporation
Dassault Systemes	A French CAD/CAM Company that develops and markets CATIA and SolidWorks
Eagle	A PC based ECAD System
ECCO	An EXPRESS Compiler developed and marketed by PDTec
EDM	An EXPRESS Compiler developed and marketed by EPM
EPM	A Norwegian Product Data Modeling Software Company
EXPRESS Data Manager	A Suite of tools for application development and integration developed and marketed by EPM
EXPRESS Engine	Express Compiler developed by NIST & NASA (Formerly EXPRESSO)
FBMach	A feature-based machining system developed by Honeywel Federal Manufacturing and Technologies (formerly Allied Signal)
FEDEX	An (earlier) Express Compiler developed at NIST
FORAN	A CAD System for Ship Structural Design developed and marketed by SENER
FREEDOM	A 3D ECAD System developed and marketed by Zukan-Redac
GibbsCAM	A CAM System developed and marketed by Gibbs and Associates
ICAD	A knowledge-based engine marketed by KTI
I-DEAS	A CAD system developed and marketed by SDRC
InterData Access (IDA)	A company, now, within Spatial Technology, Inc. - Provides data analysis tools and services
Intergraph	A company that develops and markets CAD/CAM systems
IronCAD	A CAD System developed and marketed by ICAD
ISDP/GSCAD	A Shipbuilding CAD/CAM System developed and marketed by Intergraph
ITI	International TechneGroupe, Inc. - A Product Data Interoperability Tool developer and vendor
Kockcums Computer Systems (KCS)	A European company that develops and markets CAD/CAM Systems (e.g., Tribon)

Product/Vendor	Descripton
KTI	Knowledge Technologies International
LOCAM	A CAM system developed and marketed by LSC Group, Ltd
LKSoft	A German Company that develops and markets CAD/CAM/CAE Software Tools
MasterCAM	A CAM System developed and marketed by CNC Software, Inc.
Mechanical Desktop	A CAD/CAM system developed and marketed by Autodesk
Mentorgraphics	An Electrical/Electronic CAE System Vendor
Parasolid	Geometric Modeling Kernel supporting 3D surfaces and BREP solids
PDGS	Product Design Graphics System - A CAD System developed by Ford Motor Corporation
PDTec	A German Product Data Modeling Software Company
PLM	A Product Line of EDS/UGSolutions
Pro/ENGINEER (Pro/E)	A CAD System developed and marketed by PTC
PTC	Parametric Technology Corporation
SDRC	Structural Dynamics Research Corporation
SENER Ingenieria Sistemes, S.A.	A European Company that develops and markets CAD/CAM systems
SIMSMART	A process engineering simulation tool. Also the name of the Canadian company that develops and markets the tool.
Solid Edge	A PC-based CAD system marketed by Unigraphics Solutions
SolidWorks	A PC-based CAD System marketed by Dassault Systemes (Developed by SolidWorks Corporation, now a subsidiary of Dassault)
SmartCAM	A CAM system developed and marketed by SDRC
Spatial Technology, Inc.	Develops and markets ACIS and ACIS based tools
STEP Tools, Inc.	Provides STEP related tools, translators, and services
SurfCAM	A CAM system developed and marketed by SDRC
Theorem Solutions	A Product Data Exchange Software Tool Company in the UK
Tribon	A CAD System for Ship Structural Design developed and marketed by Kockums Computer Systems (KCS)
Unigraphics	A CAD system developed and marketed by UGSolutions
Unigraphics Solutions (UGSolutions)	Develops and markets Unigraphics, Solid Edge, Bravo, and Parasolid
Visula	A CAE System developed and marketed by Zuken Redac
Zuken Redac	An Electrical/Electronic CAE System Vendor

1. Introduction

The STandard for the Exchange of Product model data (STEP - ISO 10303) provides a neutral computer-interpretable representation of product data throughout the life cycle of a product, independent of any particular system. STEP is actually a suite of international standards built around an integrated architecture of domain specific application protocols (AP) and generic integrated resources. The AP's break STEP into manageable and comprehensible "chunks" that can be more readily implemented.

Almost everyone involved with product design and/or manufacture, whether it is mechanical, electrical/electronic, or electromechanical, agrees on the importance of being able to exchange product data effectively among contractors/customers and subcontractors/suppliers who often use different CAD/CAM/CAE systems. Manufacturing is frequently outsourced. Accurate, complete product data is essential for the production and procurement of quality products. The issue of "standards" usually comes up in discussions about data exchange.

In this handbook, we will present a brief introduction to STEP along with an indication of how the ISO Standardization Process works relative to STEP. The current status of STEP development will be presented with emphasis on those parts of STEP that have achieved International Standard (IS) status and those parts that are currently being developed.. The scopes of these STEP Application Protocols (AP's) are presented to indicate what is and isn't addressed in the AP's. This information is presented so that the engineering user is able to see the depth of coverage of the AP's and to identify those STEP AP's and their associated conformance classes that best will meet the user's product data exchange (PDE) requirements.

The handbook is intended as a collection of information on the current state of STEP and it's current usability. It is intended to provide information of value to engineering users with a need to exchange product data with customers and/or suppliers.

It identifies the application domains being covered by STEP development and the tools that are commercially available for using STEP. It provides some guidance on using the STEP technology that is currently available and cites sources of additional information.

2. Background

2.1 ISO 10303 (STEP) Overview

(from http://www.ukceb.org/step)

"STEP, Standard for the Exchange of Product Model Data, provides a representation of product information along with the necessary mechanisms and definitions to enable product data to be exchanged. The exchange is among different computer systems and environments associated with the complete product lifecycle including design, manufacture, utilisation, maintenance, and disposal. The information generated about a product during these processes is used for many purposes. This use may involve many computer systems, including some that may be located in different organisations. In order to support such uses, organisations must be able to represent their product information in a common computer-interpretable form that is required to remain complete and consistent when exchanged among different computer systems.

STEP is organised as a series of parts, each published separately. These parts fall into one of the following series: description methods, integrated resources, application protocols, abstract test suites, implementation methods, and conformance testing. STEP uses a formal specification language, EXPRESS, to specify the product information to be represented. The use of a formal language enables precision and consistency of representation and facilitates development of implementations. STEP uses application protocols (APs) to specify the representation of product information for one or more applications. It is expected that several hundred APs may be developed to support the many industrial applications that STEP is expected to serve.

An addition to the STEP standard that certainly will enhance its implementability and acceptance is the constraint that abstract test suites and conformance testing must be built into the standard.

The overall objective of STEP is to provide a mechanism that is capable of describing product data throughout the life cycle of a product, independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving. The ultimate goal is an integrated product information database that is accessible and useful to all the resources necessary to support a product over its lifecycle."

For more information on STEP, the reader is referred to some of the following introductory texts on STEP**:**

1. Introducing STEP - The Foundation for Product Data Exchange in the Aerospace and Defence Sectors, National Research Council Canada, C2-447/1999, Susan Gilles (ed), 1999.
2. STEP-The Grand Experience, NIST, Sharon J. Kemmerer (ed.), July 1999
3. STEP:Towards Open Systems-STEP Fundamentals and Business Benefits, Dr. Kais Al-Timimi & John MacKrell, CIMdata, September, 1996.

Several Websites to visit for Introductory/Background Information on STEP are the following:

1. Team SCRA - RAMP Product Data --- http://isg.scra.org/teams/step.html
2. PDES Inc. Public Website --- http://pdesinc.aticorp.org/
3. PDES, Inc. STEP Overview --- http://pdesinc.aticorp.org/whystep.html
4. NIST SC4 Website (Updated 2001-11-28): --- http://www.nist.gov/sc5/soap/
   --- STEP On A Page
5. UK Council for Electronic Business (UKCEB) Website --- http://www.ukceb.org/step/
   "STEP-A Key Tool in the Global Market" (Overview) --- Nice History of STEP
6. ProSTEP --- http://www.prostep.org/de/stepportal/was/ (In German)
7. Canadian Handbook: Introducing STEP --- http://strategis.ic.gc.ca/SSG/ad03581e.html

A very useful compact summary of the STEP development process with a periodic status update was developed by Jim Nell (@ NIST). Jim is the chairman of ISO TC184/SC5, but was a long time participant in the working groups of ISO TC184/SC4 (the "home" of STEP). Jim conceived the concept of "STEP On A Page" (SOAP). On the front and back of a single "piece of paper", he was able to capture a description of all of the STEP documents and a summary of their development status which he continues to maintain/update on a periodic basis. SOAP appears below. SOAP can be found @ http://www.nist.gov/sc5/soap/

PDES, Inc. also created a set of easy to understand graphics that describe the STEP Application Protocols which can be referred to as "User Friendly AP's on a Page". They can be found at the PDES, Inc. Public Web Site @ http://pdesinc.aticorp.org/whystep.html

Over the years, the International STEP community has worked very closely within the ISO TC184/SC4 working groups with international meetings occurring 3 or 4 times a year. Within most of the countries, national STEP Centers have been established. Often, as important issues would arise or affirmation of commitments were felt to be appropriate, Memoranda of Understanding (MOU's) would be signed and issued as "Press Releases". Several of the more important MOU's were the MOU's signed (in the mid to late 1990's) by the international aerospace, automotive, and shipbuilding companies and government agencies committing to the support of STEP development and implementation. Some of the more recent MOU's were: (see http://pdesinc.aticorp.org/ & its archives)

⇒ the 1997 MOU on the harmonized STEP PDM Schema (viz., for AP's 203, 210, 212, 214, & 232) signed by ProSTEP, PDES, Inc., and JSTEP,
⇒ the 1998 MOU on the use of the STEP PDM Schema for the EuroFighter signed by BAe (UK), DASA (Germany), CASA (Spain), and Alenia (Italy),
⇒ the 1999 MOU on Modular Development and Implementation sign by PDES, Inc., ProSTEP, GOSET, and JSTEP, and
⇒ the 1999 MOU on Conformance Testing and Certification signed by PDES, Inc., GOSET, JSTEP, and C-STEP.
⇒ the 1999 Memorandum of Understanding (MOU) between NAFEMS and PDES, Inc.,
⇒ the 1999 MOU between PDES, Inc. and ProSTEP to define a Joint Work Plan for developing, testing, and implementing STEP capability.

- ⇒ the 1999 agreement between PDES, Inc. and ProSTEP on version 1.1 of the Unified PDM Schema.
- ⇒ the 1999 terms of reference for International STEP Centers (ISC) signed by PDES, Inc., ProSTEP, GOSET, JSTEP. AUSDEC, SWEDSTEP, and UNINOVA.
- ⇒ 2001 MOU between EMSA, JMSA, the Korean STEP Center, and NIDDESC

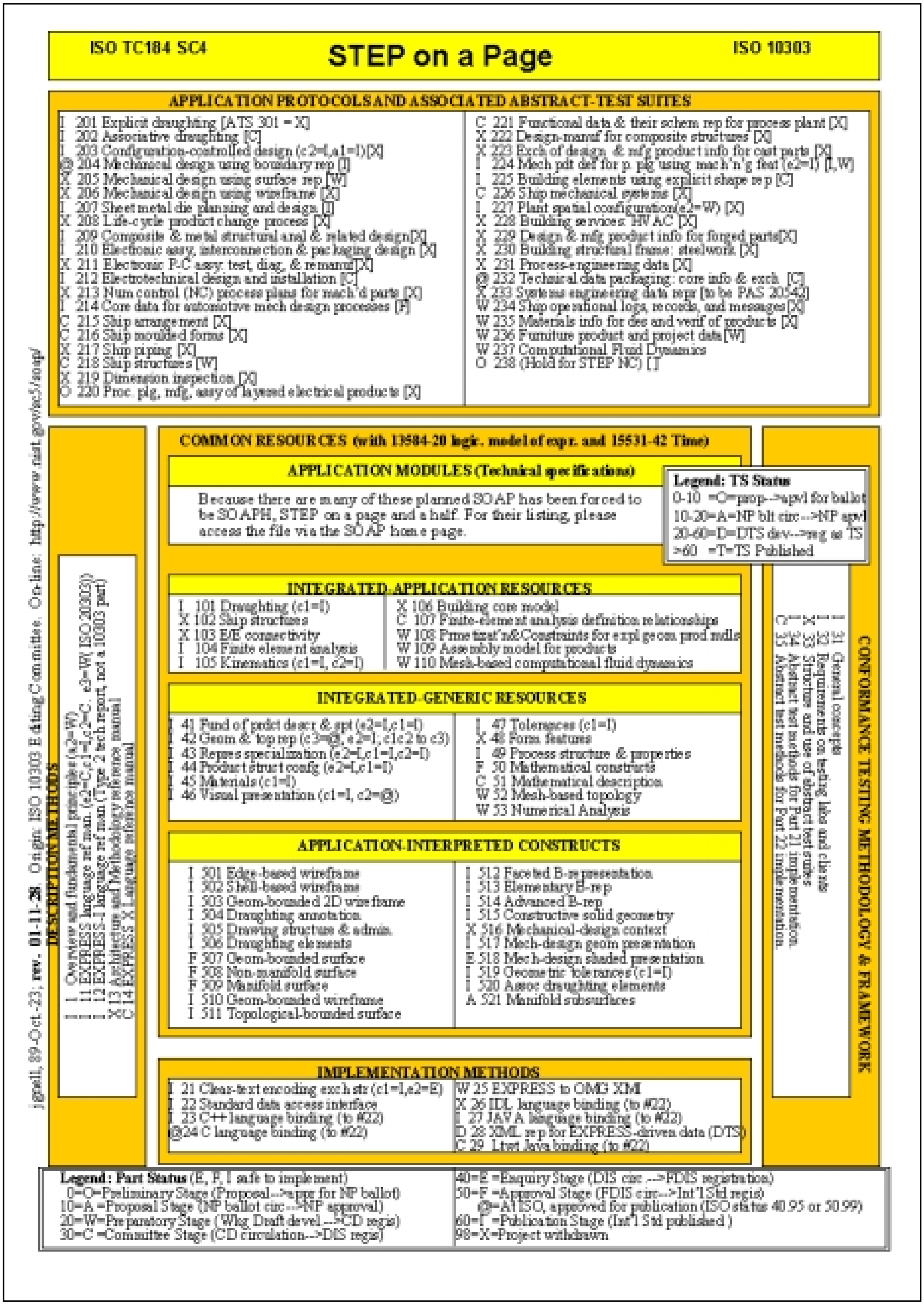

Figure 1: STEP On A Page (Front)

ISO TC184 SC4 — **STEP on a Page** — ISO 10303

STEP on a Page provides a graphic summary of the progress of STEP, Standard for the Exchange of Product Model Data, the familiar name for ISO 10303. ISO TC184 SC4, Industrial-Automation Systems and Integration/Industrial Data develops the STEP standard.

Status of STEP Parts

Every part shown in the STEP on a Page has its status shown beside it. The status designators vary from "O" (the ISO preliminary stage) to "I" (International Standard--the stage in which the standard is published). Parts designated as "E, F" (levels of Draft International Standard) and "I" are considered advanced enough to allow software vendors to prepare implementations. The legend at the bottom of the page lists the corresponding ISO-project stage numbers next to the letter code.

Architecture of STEP

STEP on a Page attempts to show the STEP architecture by grouping the STEP parts into five main categories: description methods, implementation and conformance methodology, common resources, abstract-test suites, and application protocols.

Description Methods

From an architectural perspective, the description methods group forms the underpinning of the STEP standard. This includes part 1, Overview, which also contains definitions that are universal to the STEP. Also in that group, part 11, EXPRESS Language Reference Manual, describes the data-modeling language that is employed in STEP. Parts in the descriptive-methods group are numbered from 1 to 19.

Implementation & Conformance

The STEP implementation-methods group, the 20s series, describes the mapping from STEP formal specifications to a representation used to implement STEP.

The conformance-testing-methodology-framework group, the 30s series, provides information on methods to test software-product conformance to the STEP standard, guidance for creating abstract-test suites, and the responsibilities of testing laboratories. The STEP standard is unique in that it places a very high emphasis on testing, and actually includes these methods in the standard itself.

Common Resources (IR, AIC, and AM)

At the next level is the common-resources group, the parts that contain the generic-STEP-data models. The common resources were formerly called integrated-information resources. These data models can be considered the building blocks of STEP, and they can help AP integration and interoperability because entities in the common-resources group are shareable across the application protocols that need them.

Categories of common resources are generic resources, application resources, and application-interpreted constructs, application modules, plus the Logical model of ISO 13584-20 and the Time model of ISO 15531-42. Integrated-generic resources are generic entities that are used as needed by application protocols (AP below). Parts within generic resources have numbers between 40 and 60, and are used across the entire spectrum of STEP APs. The integrated-application resources contain entities that have slightly more context than the generic entities. The parts in the integrated-application resources are numbered in the 100s.

The 500 series are application-interpreted constructs, AICs. These are reusable groups of information-resource entities that make it easier to express identical semantics in more than one AP.

Application Modules are reusable groups of functional information requirements of applications that extend the AIC capability. The functional groups, defined in enterprise-application terms, are aligned with groups of integrated-generic resources. The application modules comprise the 1000 series of parts, which are technical specifications that achieve consensus at the Committee stage. AMs offer an opportunity to represent functional capability in multiple APs with a lower standards-development cost.

Abstract-Test Suites (ATS)

The 300 series of parts, abstract-test suites, consists of test data and criteria that are used to assess the conformance of a STEP software product to the associated AP. SC4 requires that every AP contain or be associated with an abstract-test suite. The numbers assigned to ATSs exceed the AP numbers by exactly 100. Therefore, ATS 303 applies to AP203. On the graphic, the ATS status is shown in brackets, [ ], following the AP name.

Application Protocols (AP)

At the top level of the STEP hierarchy are the more complex data models used to describe specific product-data applications. These parts are known as application protocols and describe not only what data is to be used in describing a product, but also how the data is to be used in the model. The APs use the integrated-information resources in well-defined combinations and configurations to represent a particular data model of some phase of product life. APs are numbered in the 200s. APs currently in use are the Explicit Draughting AP 201 and the Configuration Controlled Design AP 203.

ooOOoo

STEP on a Page was conceived and implemented by Jim Nell, National Institute of Standards and Technology. Updated 01-June-07

Figure 2: STEP On A Page (Back)

2.2 Existing/Active STEP Application Protocols

The following list includes STEP Application Protocols that are active.

AP201:1994	**IS**	Explicit draughting
AP202:1997	**IS**	Associative draughting
AP203:1994	**IS**	Configuration controlled 3D designs of mechanical parts and assemblies
AP204	**FDIS**	Mechanical design using boundary representation
AP207:1999	**IS**	Sheet metal die planning and design
AP209:2001	**IS**	Composite and metallic structural analysis & related design
AP210:2001	**IS**	Electronic assembly, interconnection and exchange
AP212:2001	**IS**	Electrotechnical design and installation
AP213	**DIS**	Numerical control process plans for machined parts
AP214:2001	**IS**	Core data for automotive mechanical design processes
AP215	**CD**	Ship arrangement
AP216	**DIS**	Ship moulded forms
AP218	**CD**	Ship structures
AP219	**PWI**	Manage dimensional inspection of solid parts or assemblies
AP220	**PWI**	Process planning, manufacturing, assembly of layered electrical products
AP221	**CD**	Functional data and their schematic representation for process plants
AP223	**PWI**	Exchange of design and manufacturing product information for cast parts
AP224:1999 (1st Ed)	**IS**	Mechanical product definition for process planning using machining features
AP224:2001 (2nd Ed)	**IS**	Mechanical product definition for process planning using machining features (includes assemblies)
AP225:1999	**IS**	Building elements using explicit shape representation
AP226	**CD**	Ship mechanical systems
AP227:2001 (1st Ed)	**IS**	Plant spatial configuration
AP227 (2nd Ed)	**CD**	Plant spatial configuration (includes ship piping and HVAC)
AP229	**PWI**	Design and manufacturing product information for forged parts
AP230	**WD**	Building structural frame: steelwork
AP231	**CD**	Process design and process specifications of major equipment
AP232:2002	**IS**	Technical data packaging core information and exchange
AP233	**WD**	Systems engineering data representation
AP234	**AWI**	Ship operational logs, records, and messages
AP235	**WD**	Materials information for the design and verification of products
AP236	**WD**	Furniture product data and project data
AP237	**AWI**	Computational Fluid Dynamics
AP238	**PWI**	STEP-NC
AP239	**AWI**	Product Life Cycle Support

Where

PWI Preliminary Work Item
AWI Approved Work Item
WD Working Draft
CD Committee Draft
DIS Draft International Standard
FDIS Final Draft International Standard
IS International Standard

See the PDES, Inc. public web site: http://pdesinc.aticorp.org/whatsnew/all_aps.html for "user friendly" graphics describing most of the STEP AP's individually "on a page".

PDES, Inc., along with other STEP organizations worldwide, has put forth an initiative to develop STEP Application Modules (AM's) that are domain, or even complete AP, building blocks. The initial set of AM's (1001-1009) have been published as ISO Technical Specifications (TS) in 2001. This effort is aimed at significantly speeding up the ISO standardization process. The AM initiative has widespread support, particularly from the user community. The next set of 64 AM’s started the four (4) month CD/TS ballot cycle on 2001-10-17. These are the Product Data Management (PDM) Application Modules, and are being balloted as eight (8) packages of AM’s.

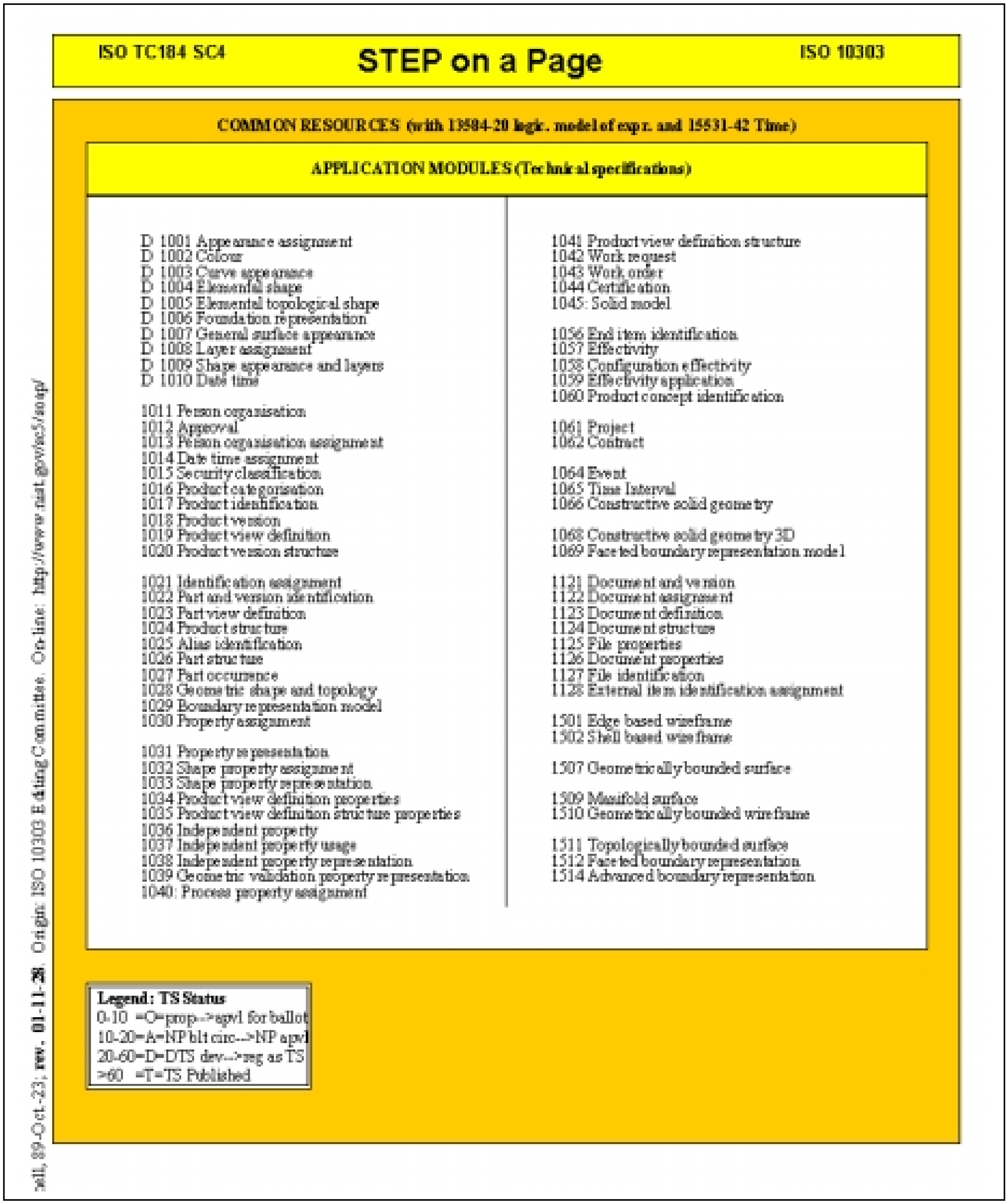

Figure 3: STEP On A Page (AM Supplement)

AP203 (Edition 2) will be developed using AM's and is expected to be balloted in 2002 as a Technical Specification. It will include the PDM AM's (replacing the current Configuration Management (CM) conformance classes (cc1a & 1b)), colors and layers, validation properties, and the construction history and dimensions and tolerance modules which are under development and will be balloted as AM's in 2002. AP221 (Functional data and their schematic representation for process plants), AP233 (Systems engineering), and AP239(?) (Product life cycle support) and the Engineering Analysis Core Model (EACM) have also committed to a modular approach.

In an attempt to "streamline procedures, the ISO Central Secretariat Council has introduced several "new", more flexible, paths along which ISO **normative** documents can be developed. Two such paths are the Publicly Available Specification (PAS) and the Technical Specification (TS).

(See http://www.iso.ch/iso/en/stdsdevelopment/whowhenhow/proc/deliverables/pasetc.html)

The ISO/PAS is a "normative document representing the consensus within a working group (WG)." A PAS only requires a simple majority of P-members of the TC/SC under which the WG operates. It is reviewed after 3 years. It may be renewed as a PAS for 3 more years (max), revised, processed to International Standard Status, or withdrawn. There can be competing PAS's as long as none of them conflicts with existing standards.

PAS 20542 (AP233) (See 2.7.14 & 2.8.5) Systems Engineering is taking this route building on the earlier work of the International Council On Systems Engineering (INCOSE).

The ISO/TS is similar. The ISO/TS is a "normative document representing the **technical** consensus within an ISO committee." This is a route that many TC184/SC4 documents are now taking. All of the Application Modules and Abstract Test Suites, as well as Part 25, Part 28, and the 2nd Edition of AP203 will be balloted as TS's. TS ballots are three months and require approval of 2/3 of the P-members of the TC to be published as an ISO/TS. TS's, too, may be renewed as a TS for 3 more years (max), revised, processed to International Standard Status, or withdrawn.

"A standard developed outside of an ISO committee (can be) submitted for fast-track processing. The standard is submitted directly as an ISO/DIS for a five month vote, and the same approval criteria … apply" as for conventional DIS ballots.

The following table identifies the stages in the ISO Standardization Process. The process of reaching international consensus on a standard can be and often is very arduous. STEP Application Protocol development, from the initial proposal for a new project (the Preliminary Work Item) to the publication of the International Standard, often has taken five (5) or more years to complete.

2.3 International Harmonized Stage Codes

STAGE	SUBSTAGE						
	00	**20**	**60**		**90**	**Decision**	
	Registration	**Start of Main Action**	**Completion of Main Action**	**92 Repeat of Earlier Phase**	**93 Repeat Current Phase**	**98 Abandon**	**99 Proceed**
00 Preliminary Stage	00.00 Proposal for new project received	00.20 Proposal for new project under review	00.60 Review summary circulated			00.98 Proposal for new project abandoned	00.99 Approval to ballot proposal for new project
10 Proposal Stage	10.00 Proposal for new project registered	10.20 New Project ballot initiated *4 months*	10.60 Voting summary circulated	10.92 Proposal returned to submitter for further definition		10.98 New project rejected	10.99 New project approved
20 Preparatory Stage	20.00 New project registered in TC/SC work program	20.20 Working Draft (WD) study initiated	20.60 Comments summary circulated			20.98 Project deleted	20.99 WD approved for registration as CD
30 Committee Stage	30.00 Committee Draft (CD) registered	30.20 CD study/ballot initiated *4 months-1st* *3 months-2nd+*	30.60 Comments/ voting summary circulated	30.92 CD referred back to working group		30.98 Project deleted	30.99 CD approved for registration as DIS
40 Enquiry Stage	40.00 DIS registered	40.20 DIS ballot initiated *5 months*	40.60 Voting summary dispatched	40.92 Full report circulated: DIS referred back to TC or SC	40.93 Full report circulated: decision for new DIS ballot	40.98 Project deleted	40.99 Full report circulated: DIS approved for registration as FDIS
50 Approval Stage	50.00 FDIS registered for formal approval	50.20 FDIS ballot initiated: *2 months.* Proof sent to secretariat	50.60 Voting summary dispatched. Proof returned by secretariat	50.92 FDIS referred back to TC or SC		50.98 Project deleted	50.99 FDIS approved for publication
60 Publication Stage	60.00 International Standard under publication		60.60 International Standard published				
90 Review Stage		90.20 International Standard under periodical review	90.60 Review summary dispatched	90.92 International Standard to be revised	90.93 International Standard confirmed		90.99 Withdrawal of International Standard proposed by TC or SC
95 Withdrawal Stage		95.20 Withdrawal ballot initiated	95.60 Voting summary dispatched	95.92 Decision not to withdraw International Standard			95.99 Withdrawal of International Standard

Figure 4: ISO Stage Codes

Examples of the principal abbreviations used in the technical program

The following table gives examples of the principal abbreviations used in the ISO technical program, together with an indication of the corresponding project stage.

Stage	Abbreviation		Description
20 Preparatory stage	20.00	AWI AWI Amd AWI TR or TS	Approved Work Item, no working draft yet available. Approved proposal for an Amendment Approved proposal for a Technical Report or a Technical Specification
	20.20	WD WD Amd WD TR or TS	Working Draft Working draft of an Amendment Working draft of a Technical Report or a Technical Specification
30 Committee stage		CD CD Amd CD Cor CD TR or TS DTR *PDAmd*	Committee Draft Committee draft of an Amendment Committee draft of a Technical Corrigendum Committee draft of a Technical Report or a Technical Specification Draft Technical Report *Proposed draft amendment*
40 Enquiry stage		DIS DAmd *FCD* *FPDISP*	Draft International Standard Draft Amendment *Final Committee draft* *Final proposed Draft International Standardized Profile*
50 Approval stage		FDIS FDAmd PRF PRF Amd PRF TR or TS PRF Suppl	Final Draft International Standard Final draft amendment Proof of a new International Standard Proof of an Amendment Proof of a Technical Report or a Technical Specification Proof of a Supplement
60 Publication stage		ISO ISO/TR or TS Amd Cor	International Standard Technical Report or Technical Specification Amendment Technical Corrigendum

Figure 5 ISO Stage Abbreviations

NOTES RELATING TO THE ABOVE TABLE

- The abbreviations in italics apply only to the projects of ISO/IEC JTC 1.
- The abbreviations **AWI** (approved work item) and **PRF** (proof) do not appear in the *ISO/IEC Directives, Part 1: Procedures for the technical work*, 1995, but have been added here to reflect the current options. AWI is only used for stage 20.00 (new project

registered in TC/SC work program) and PRF is applied in cases where projects are passing through the approval stage (50) without being subject to a FDIS ballot.

2.4 Comments on STEP AP's, AIC's, AM's and RPG's

STEP development is reaching a point at which numerous STEP Standards are reaching closure and stability. There are now twelve (12) Application Protocols that have achieved IS status. It would seem that this is an opportune point in time for CAD/CAM Vendors to expand their implementation coverage.

There are conformance classes (cc) associated with each AP. Conformance classes are subsets of an AP that can be implemented "meaningfully" within that application domain without having to implement all aspects of the AP. Implementation of selected conformance classes can be seen in those AP's that have been commercially implemented to date (viz., AP's 203 and 214).

As an engineering user, it will be important to know what conformance classes of an AP have been implemented. It is not enough to indicate that a Vendor has a STEP or an APxxx translator. The engineering user will need to know what conformance classes of APxxx have been implemented and to understand the coverage of those conformance classes. As examples: AP203 has 12 conformance classes (1a,b through 6a,b). Very few Vendors who claim to have an AP203 translator have implemented cc 5a,b; most have implemented cc's 2a, 4a & 6a (i.e., with a "minimal" (but acceptable, by consensus) subset of Configuration Management data (viz., cc1a)). Most vendors who claim to have an AP214 translator have only implemented cc1 and/or cc2 that are essentially identical to AP203 geometry/topology with a somewhat different set of configuration management data. Note that AP214 has 20 conformance classes; these 20 conformance classes cover essentially the entire spectrum of automotive design. It is misleading, at this point, for Vendors to claim that they have implemented AP214 without qualifying that statement with the conformance classes that have been implemented. Almost all commercially available AP214 translators address only the AP203 "look alike" conformance classes (i.e., AP214 cc's 1 & 2). It should be noted that some of the Vendors now have prototype implementations of the PDM conformance classes (cc 6 & 7) of AP214. Extensive effort has been expended in harmonizing the PDM Schema with those STEP AP's addressing PDM data such as AP's 203, 209, 214, and 232.

In the following sections, the scope is given for each of the AP's that have been published as ISO 10303 standards and those that are in the process of being developed. The conformance classes associated with each of the AP's that have achieved IS status are also provided, as well as many of those that are in development. The intention here is to provide the engineering user with a view of the robustness of the STEP AP's and the potential usefulness of implementations of the associated conformance classes. As will be noted later, in the final analysis, it will be the engineering user who will drive the Vendor implementations of STEP AP conformance classes.

A concept that was created within the STEP development process was that of the Application Interpreted Construct (AIC) which could be referenced by multiple AP's and, thereby, reduce the number of pages in AP documents and assure consistency among the AP's referencing the AIC's.

The Application Module (AM) was another concept that was established to assist and accelerate STEP development and implementation. The intent of AM's is to identify and develop modules that have commonality among numerous application domains. Existing AP's could be modularized and new AP's could be built using the AM's as “building blocks”. In addition, AM's could be used to extend existing AP's as has been done with AP203 where prototype implementations have been developed and tested in the CAx - Implementors Forum (see below). As stated previously, the AM process portends to significantly reduce STEP development timelines.

STEP On A Page (SOAP), above, briefly defines and identifies AIC's and AM's.

Almost all of the current STEP AIC's (i.e., 501 - 515, 517, 519, 520) have achieved International Standard (IS) status. AIC518 is currently at Draft International Standard (DIS) status, and AIC516 was cancelled. AIC521 is new and its five (5) month DIS Ballot began In December 2001.

The AIC's are reiterated below for reference

10303-501:2000 - Edge-based wireframe
10303-502:2000 - Shell-based wireframe
10303-503:2000 - Geometrically Bounded 2D wireframe
10303-504:2000 - Draughting annotation
10303-505:2000 - Drawing structure and administration
10303-506:2000 - Draughting elements
10303-507:2001 - Geometrically bounded surface
10303-508:2001 - Non-manifold surface
10303-509:2001 - Manifold surface
10303-510:2000 - Geometrically bounded wireframe
10303-511:2001 - Topologically bounded surface
10303-512:1999 - Faceted boundary representation
10303-513:2000 - Elementary boundary representation
10303-514:1999 - Advanced boundary representation
10303-515:2000 - Constructive solid geometry
10303-517:2000 - Mechanical design geometric presentation
10303-518/DIS - Mechanical design shaded presentation
10303-519:2000 - Geometric tolerances
10303-520:1999 - Associative draughting elements
10303-521/CD - Manifold subsurface

The initial set of nine (9) Application Modules (AM) (AMs 1001-1009) were published as Technical Specifications (TS) in 2001. (http://www.nist.gov/sc4/nwi_pwi/nwi/step/sal_mods/)

This initial set of AM's is listed below:

10303-1001:2001 - Application module: Appearance assignment
10303-1002:2001 - Application Module: Colour

10303-1003:2001 - Application module: Curve appearance
10303-1004:2001 - Application module: Elemental shape
10303-1005:2001 - Application module: Elemental topological shape.
10303-1006:2001 - Application module: Foundation representation.
10303-1007:2001 - Application module: General surface appearance.
10303-1008:2001 - Application Module: Layer assignment
10303-1009:2001 - Application Module: Shape appearance and layers

The supplementary SOAP Table (see Figure 3 above) lists these and the additional 64 PDM modules being balloted as TS's from 19 October 2001 to 18 February 2002.

The currently planned Module Suites include:

- Drafting (Color/layer, Associative Text) (AM's 1001-1009)
- Product Data Management (PDM) (Being Balloted – see Figure 3)
- Construction History (in development)
- Dimensional Tolerances (in development)
- Geometric Validation Properties (in development)
- Engineering Analysis (in development)
- Exchange Management (in development)
- Systems Engineering (in development)

For more information on the concept and architecture of STEP Application Module Development, visit the following web site: http://wg10step.aticorp.org/Modules/index.htm EuroSTEP administers the STEP module repository at http://sourceforge.net/projects/stepmod .

Selective pilot/prototype testing of modular extensions of AP203 with the Colours & Layers, Associative Text, and Geometric Validation Properties modules is being done in the Joint PDES, Inc./ProSTEP CAx - Implementors Forum (CAx-IF).

Recommended Practices Guides (RPGs) exist for these modules and several others and can be found on the PDES, Inc. public web site.

"PDES, Inc. Developed Recommended Practices Documents:
http://pdesinc.aticorp.org/rec_prac.html

AP203 Recommended Practices
AP209 Recommended Practices
AP210 Concept of Operations
AP232 Recommended Practices

PDES, Inc. and ProSTEP Developed Recommended Practices Documents:

PDM Schema Usage Guide
3-D Associative Text Recommended Practices
Recommended Practices for Dimensions and Dimensional Tolerances

Recommended Practices for Form Features: Round Hole, Thread and Compound Features
Recommended Practices for Colors and Layers
Recommended Practices for Model Viewing
Recommended Practices for Geometric Validation Properties"

Other Recommended Practices Guides (RPG's) are in preparation, including AP226 and AP227.

2.5 STEP and XML, STEPml, Implementation Methods

(See http://www.stepml.org/specifications.html)

"STEPml is a library of (eXtensible Markup Language) XML specifications --- Document Type Definitions (DTDs) and/or XML Schemas --- for product data. STEPml's content is based on information models from STEP…" " STEPml is Product Data for the Web. Product data is a key enabler for process integration, supply chain management, collaborative engineering, analysis, manufacturing and customer support. Virtual enterprises using the Web need STEPml as the standard for product data schemas." STEPml implementations will enable "companies to communicate information about products within their organization and their business partners using the Web."

"This STEPml specification addresses the requirements to identify and classify or categorize products, components, assemblies (ignoring their structure) and/or parts. Identification and classification are concepts assigned to a product by a particular organization. This specification describes the core identification capability upon which additional capabilities, such as product structure, are based.

Scope statement
The following are within the scope of the STEPml specification:

- identifying products using a string value that is unique within the organization that assigned the value for a type of product;
- representing the name of a product;
- representing an optional description of a product;
- representing the categorization of the product;
- the specification of a data structure to identify an organization;
- the specification of a data structure to identify a person;
- the specification of a data structure to relate a person to an organization;
- the specification of a data structure to represent an address;
- an organization may have a related address;
- a person in an organization may have a related address;
- all identified people must be related to organizations;
- the assignment of an organization to product data;
- the assignment of a person in an organization to product data;
- specifying a data structure to record the names of categories for products;
- specifying a data structure to optionally record the description or definition of a product category;

- specifying a data structure to relate product categories in a hierarchical manner;
- optionally recording what organisation or person in organisation defines a category for a product.

The following are outside the scope of this specification:

- representing product version information;
- representing product structure (e.g. assembly or BOM) information;
- representing change management information related to a product.

These additional capabilities are or will be addressed in other STEPml specifications."

The design of the structure of STEPml markup is based on the Object Serialization Early Binding (OSEB). (See http://www.stepml.org/oseb/index.html) (See also Part 28 below.)

Part 28

Part 28 provides a representation of data according to the syntax of Extensible Markup Language (XML) defined using ISO 10303-11 (the EXPRESS language) and/or for EXPRESS schemas. The mappings are specified from the EXPRESS language to the syntax of the representation. Any EXPRESS schema or schemas and the data they describe can be represented. (Note: the original Part 28 was subsequently split into two parts --- a revised Part 28 and a Part 25. They are both being developed as Technical Specifications (TS).)

Part 25

Part 25 provides a mapping of EXPRESS into the physical meta-model of the Universal Modeling Language (UML) enabling the Object Management Group's (OMG) XML Metadata Interchange (XMI).

ISO/TS 10303-28 Implementation methods: XML representation for EXPRESS driven data

"This part of ISO 10303 specifies means by which data and schemas specified using the EXPRESS language (ISO 10303-11) can be encoded using XML. XML provides a basic syntax that can be used in many different ways to encode information. In this part of ISO 10303, the following uses of XML are specified:

a) A late bound XML architectural element declaration set that enables any EXPRESS schema to be encoded;
b) An extension to the late bound element declaration set to enable data corresponding to any EXPRESS schema to be encoded as XML;
c) An early bound declaration set that uses the late bound set as its basis;
d) The use of SGML architectures to enable further XML forms to be defined that are compatible with the late bound declaration set;
e) A mapping from the EXPRESS language to the XML Metadata Interchange format (deferred to Part 25);
f) An object based XML binding that is specialised to meet requirements for inter-process communication.

The use of architectures allows for different early bindings to be defined that are compatible with each other and can be processed using the architectural elements.

Scope

This part of ISO 10303 specifies use of the Extensible Markup Language (XML) to enable the transfer of schemas specified using the EXPRESS data specification language (ISO 10303-11) and data that is governed by EXPRESS schemas.

The following are within the scope of this part of ISO 10303.

- Specification of XML element declarations that enable any EXPRESS schema to be encoded using XML.
- Specification of XML element declarations that enable data that is governed by any EXPRESS schema to be encoded as XML. (NOTE: XML element declarations specified using this method are referred to as late bound, in that they are independent of any EXPRESS schema. This specification allows for a number of choices for encoding the data.)
- Methods for the specification of XML element declarations that enable data that is governed by a specific EXPRESS schema to be encoded as XML, where the mapping from the EXPRESS language and XML is independent of the characteristics of any specific EXPRESS schema. (NOTE: XML element declarations specified using these methods are referred to as early bound, in that they are specific to a given schema.)
- Methods for the specification of the correspondence between XML element declarations that enable encoding of data governed by a specific schema (early bound) and XML element declarations that enable encoding of data governed by any schema (late bound).
- Specification of a mapping from EXPRESS to the XML Metadata Interchange (XMI) Document Type Definition (see Part 25).

The following are **outside** the scope of this part of ISO 10303.

- Methods for the specification of XML declarations that enable data that is governed by a specific EXPRESS schema to be encoded as XML, where the mapping from the EXPRESS language and XML is dependent on the characteristics of the specific EXPRESS schema.
- Specification of mappings from XML element declarations to an EXPRESS schema. (NOTE: Given a set of XML element declarations and one or more corresponding data sets, it is feasible to create an EXPRESS schema that describes the data. However, this requires an understanding of the meaning and use of the data that may not be captured by the XML element declarations.)
- Methods for recreation of an EXPRESS schema from an XML encoding of that schema;
- Methods for recreation of an EXPRESS schema from XML element declarations that have been derived from the schema."

A Second Edition of Part 28 is being developed based on the Simple Object Access Protocol (SOAP). This, too, will be balloted as a Technical Specification.

ISO/TS 10303-25 Implementation methods: EXPRESS to OMG XMI binding

"The Object Management Group (OMG) has standardized the XML Metadata Interchange specification (XMI) that integrates the OMG Unified Modeling Language (UML) , the OMG Meta-Object Facility (MOF) and the World Wide Web Consortium (W3C) Extensible Markup Language (XML) standards. XMI is a mechanism for the interchange of metadata between UML-based modeling tools and MOF-based metadata repositories. OMG has also standardized an XMI compliant interchange format for the UML thus specifying a lexical representation of UML models based on a standardized metamodel of the UML. That lexical representation includes, among other things, the ability to interchange data type information, class information (or entities), groupings of classes providing namespaces for the classes (or schemas), associations between classes and inheritance between classes (or subtypes)."

This part of ISO 10303 specifies a mapping of EXPRESS constructs into the UML Interchange Metamodel for XMI use.

The following are **within** the scope of this part of ISO 10303:

- Mappings for EXPRESS constructs that appear in UML Static Structure Diagrams;

The following are **outside** the scope of this part of ISO 10303:

- Mappings of EXPRESS constructs into UML for purposes other than XMI use;
- Mappings for EXPRESS expressions into any representation in XMI;
- Mappings from UML into EXPRESS.

Implementations of this part of ISO 10303 shall support one or more of the following mechanisms for interchange based on the mappings specified in this part of ISO 10303:

- the XMI 1.1 based UML 1.4 DTD;
- the XMI 1.0 based UML 1.3 DTD;
- the XMI 1.1 based UML 1.3 DTD;
- any later XMI or XMI-related specification defining a representation of UML 1.4 (or UML 1.4 equivalent UML 1.3) for UML model interchange."

Not all EXPRESS constructs are mapped as UML. UML does not support everything that EXPRESS supports. EXPRESS schemas, being data specifications, are mapped into concepts in UML that appear in UML Static Structure Diagrams.

Some of the on-going activities in the STEP/XML area are listed below:

- ♦ The STEPml Team is developing XML Document Type Definition (DTD) versions of the STEP Product Data Management (PDM) modules.
- ♦ NIST is creating an EXPRESS to XML tool. STEP Tools, Inc. already has developed EXPRESS to XML tools using both an Object Serialization Early Binding (OSEB) and a Containment Early Binding (CEB).

- NIST has also created a Repository for XML representations of the STEP Application Modules. (See http://ats.nist.gov/stepmod/repo.html)
  (See also http://www.steptools.com/products/strepo/)
- The ESTEP Shipbuilding Project is developing a Part 28 implementation for AP227 (Edition 2).
- STEP-NC data are also being generated in both OSEB and CEB XML formats.

In the following two (2) sections, the scope is given for each of the AP's that have been published as ISO 10303 standards and those that are still in the process of being developed. The conformance classes associated with each of the AP's that have achieved IS status are also provided, as well as many of those that are still in development. The intention here is to provide the engineering user with a view of the robustness of the STEP AP's and the potential usefulness of implementations of the associated conformance classes. It is the engineering user who must drive commercial (or internal) implementations of STEP AP conformance classes.

2.6 Scopes and Conformance Classes of Application Protocols (AP) with IS Status

Many of these scope descriptions are taken from the SC4 Project Management Database that was last updated on SOLIS (http://www.nist.gov/sc4/sc4dbase/) on September 29, 2001. The conformance class descriptions are taken from Clause 6 of the International Standard (IS), Draft International Standard (DIS), or Committee Draft (CD) document as appropriate for the current stage of the AP. The AP's which have achieved IS status are listed first.

It should be noted that a conformance class of an ISO 10303 Application Protocol specifies a meaningful part of the AP, **all** of which must be supported by an implementation. Conformance to a particular conformance class requires that all AIM entities, types, and associated constraints defined as part of that class be supported. Conformance to a particular conformance class requires conformance to each conformance class included in that class. Conformance to a particular conformance class requires that all Application Resource Model (ARM) constraints for the Units of Functionality (UoF's) implemented by this class be supported. (Clause 6 of the Standard spells out the details of each conformance class.)

This section is intended to give the engineering user insight into the coverage of the specific AP to assist in determining what an implementation of some or all of the conformance classes of this AP can provide to this user. If more detail is needed, the reader is referred to Clause 6 of the Standard itself.

2.6.1 AP201: Explicit draughting (ISO 10303-201:1994)

"This part of ISO 10303 is applicable to the inter-organization exchange of computer-interpretable drawing information and product definition data.

The following are **within** the scope of this part of ISO 10303:

- The representation of drawings for the purpose of exchange, especially for mechanical engineering, architectural engineering, and construction applications;
- The representation of the real size of a product depicted in a drawing to enable use by applications where true geometric equivalence is required;

(The representation of the shape of the product is required to support not only visual equivalence of exchanged drawings but also where true geometric equivalence is required by the receiving system. Such uses include the calculations of distances or areas and the generation of numerical control tool paths.)

- The representation of a drawing that depicts any phase of the design;
- The representation of individual drawing revisions;
- The representation of the two-dimensional draughting shape model depicting the product shape and the Transformations used for the generation of the drawing views;
- The presentation of non-shape product definition data depicted in a drawing by tow-dimensional annotations;
- The hierarchical structure of drawings, drawing sheets, and views of the draughting shape model;
- The mechanisms for the grouping of the elements depicted on a drawing;
- The administrative data used for the purpose of drawing management;
- The administrative data identifying the product versions being documented by the drawing.

The following are **outside** the scope of this part of ISO 10303:

- The representation of the shape of a product using three-dimensional geometry;
- The representation of the shape of a product that is not depicted in a drawing;
- The representation of drawings that are not related to a product;
- The exchange of drawing history;
- The definition of annotation in three-dimensional coordinate systems;
- The presentation of dimensions and annotation that are associated to viewed geometry and annotation;
- A computer-interpretable bill of material structure except as conveyed by annotation on the drawing;
- Strict enforcement of draughting standards;
- Drawings containing non-displayable attribute data other than that required as administrative data (e.g., density, mass, or moment of inertia);
- The automatic generation of drawings including views, dimensions, and annotation.
- The exchange of data used exclusively for the creation of paper or hardcopy versions of the drawing (e.g., pen designations, plot scale, or plot color specifications)."

AP201 is a single Conformance Class.

cc: Explicit draughting

2.6.2 AP202: Associative draughting (ISO 10303-202:1996)

"This part of ISO 10303 provides for the inter-organization exchange of computer-interpretable drawing information and associated product definition data.

The following are **within** the scope of this part of ISO 10303:

- ♦ The structures for representing drawings for the purpose of exchange, suitable for mechanical engineering and Architecture, Engineering, Construction (AEC) applications;
- ♦ The structures for representing a drawing that depicts any phase of the life cycle of a product;
- ♦ The structures for representing individual drawing revisions;
- ♦ The structures for representing the two-dimensional or three-dimensional product shape;
- ♦ The structures for representing the transformations of the shape model used for the generation of the drawing views;
- ♦ The hierarchical structure of drawings, drawing sheets, and views of the draughting shape model;
- ♦ The presentation of non-shape product definition data depicted in a drawing by two-dimensional annotation or planar annotation defined in a three-dimensional coordinate space;
- ♦ Mechanisms for the grouping of the elements depicted on a drawing;
- ♦ The administrative data used for the purpose of drawing management;
- ♦ The administrative data identifying the product versions being documented by the drawing;
- ♦ The structures for representing associations between dimensions or draughting callouts and their respective target product shape geometry or annotation;
- ♦ The structures for representing associations between the boundaries of a fill area and the product shape geometry or annotation from which they are derived;
- ♦ Seven classes of draughting shape models used to represent product shape which include advanced boundary representation, faceted boundary representation, elementary boundary representation, manifold surfaces with topology, surface or wireframe geometry without topology, wireframe geometry with topology, and elementary curve sets;
- ♦ The presentation of dimensions and annotation that may be, but need not be, associated with viewed geometry or annotation.

The following are **outside** the scope of this part of ISO 10303:

- ♦ A draughting shape model that is not depicted in a drawing nor used as a constituent of another draughting shape model;
- ♦ The structures for representing drawings that are not related to a product;
- ♦ The structures for defining the relationship between multiple drawings;

Drawings could be related to document the assembly structure of a part or define the history between multiple versions of the same drawing.

- ♦ Non-planar annotation defined in a three-dimensional coordinate space;
- ♦ A bill of material presented on the drawing by annotation where the information is interpretable to a computer as a bill of materials;
- ♦ Enforcement of conventions and rules found in draughting standards;

This part of ISO 10303 supports the use of draughting standards but does not redefine them.

- The exchange of non-displayable attribute data other than that required as administrative data (e.g., density, mass, or moment inertia);
- The automatic generation of drawings including views, dimensions, and annotations;
- The exchange of data used exclusively for the creation of paper or hard copy versions of the drawing (e.g., pen designations, plot scale, or plot colour specifications);
- The presentation of the shape of a product in a two-dimensional view using light sources and shading;
- The association between geometric tolerances and related geometric elements;

A geometric tolerance as described above is a combination of geometric characteristics symbols, tolerance values, and datum references, where applicable, to express the permissible variation from the theoretically exact size, profile, orientation, or location of a feature or datum target. Each of the three possible components, geometric characteristic symbols, tolerance values, and datum references are computer-identifiable but not computer-interpretable and, therefore, cannot be associated to geometric elements.

- The association between computer-recognizable limit dimensions and shape geometry or annotation."

AP202 has 10 Conformance Classes:

The conformance classes are characterized as follows:

cc 1: Administration, annotation, data organization (layers, groups), and drawing structure presentation (colors, fonts) without shape
cc 2: cc 1 and elementary 2D geometrically bounded wireframe
cc 3: cc 1 and all 2D geometrically bounded wireframe
cc 4: cc 1 and 2D topological wireframe
cc 5: cc 1 and 3D geometrically bounded wireframe and/or surfaces
cc 6: cc 1 and 3D topological wireframe
cc 7: cc 1 and faceted B-Rep
cc 8: cc 1 and elementary B-Rep
cc 9: cc 1 and advanced B-Rep
cc 10: cc 1 and manifold surface models with topology

2.6.3 **AP203: Configuration controlled 3D designs of mechanical parts and assemblies (ISO 10303-203:1994)**

" The following are **<u>within</u>** the scope of this part of ISO 10303:

- Products that are mechanical parts and assemblies;
- Product definition data and configuration control data pertaining to the design phase of a product's development;
- The change of a design and data related to the documentation of the change process;
- Five types of shape representations of a part that include wireframe and surface without topology, wireframe geometry with topology, manifold surfaces with topology, faceted boundary representation, and boundary representation;

- Alternate representation of the data by different disciplines during the design phase of a product's life cycle;
- Identification of government, industry, company or other specifications for design, process, surface finish, and materials which are specified by a designer as being applicable to the design of the product;
- The identification of government, industry, company, or other standard parts for the purpose of their inclusion in a product's design;
- Data that are necessary for the tracking of a design's release;
- Data that are necessary to track the approval of a design; a design aspect, or a configuration control aspect of a product;
- Data that identify the supplier of either the product or the design and, where required by an organization, qualification information for the supplier;
- If a part is being designed under a contract, the identification of , and reference to, that contract under which a design is developed;
- The identification of the security classification of a single part or a part when it is a component in an assembly;
- Data that is used in, or results from, the analysis or test of a design which is used as evidence for consideration of a change to a design.

The following are **outside** the scope of part of ISO 10303:

- Data that is used in, or results from, the analysis or test of a design that is not used as evidence for consideration of a change to a design;
- Data that results in changes to the design during the initial design evolution prior to its release;
- Product definition data and configuration control data pertaining to any life cycle phase of a product's development other than design;
- The business data for the management of a design project;
- Alternate representations of the data by different disciplines outside of the design phase (e.g., manufacturing);
- The use of constructive solid geometry for the representation of objects;
- Data that pertains to the visual presentation of any of the shape or configuration control data."

AP203 (Edition 1) has 12 Conformance Classes:

The conformance classes are characterized as follows:

cc 1a, b: Configuration controlled-design information without shape (cc 1a is a specified "product identification" subset of cc 1b)
cc 2a, b: cc 1a, b and 3D geometrically bounded wireframe and/or surface models
cc 3a, b: cc 1a, b and 3D wireframe models with topology
cc 4a, b: cc 1a, b and manifold surface models with topology
cc 5a, b: cc 1a, b and faceted B-Rep
cc 6a, b: cc 1a, b and advanced B-Rep

Edition 2 - Will be Modularized – Colours & Layers, Validation Properties, Construction History, Validation Properties, Dimensions and Tolerances will be added to the scope, and the Configuration Management data (cc 1a & cc 1b) will be replaced by the PDM Schema/Modules.

2.6.4 AP207: Sheet metal die planning and design (ISO 10303-207:1999)

"This part of ISO 10303 specifies the use of the integrated resources necessary for the scope and information requirements for exchange of information between contractors and suppliers to enable the eventual manufacture of sheet metal dies used in the production process of sheet metal parts.

The following are **within** the scope of this part of ISO 10303:

- ♦ Types of product supported: (This list describes the types of product for which data is in scope. The products themselves are not in scope, because they are not data.)
  - (1) Sheet metal part design data (Sheet metal part designs may be for sheet metal parts intended for the exterior of a product, those intended for the interior of a product, those intended to be in view on the final product, or those intended to support loads or maintain structure of a product. Sheet metal part designs may also be for sheet metal parts that are products in themselves.);
  - (2) Sheet metal die design data, including die face design and die structure design, for an individual die against which sheet metal is formed by processes that do not involve a mating die;
  - (3) Sheet metal die set design data, including die face design and die structure design, for die sets used in a stamping press machine to manufacture sheet metal parts;
  - (4) Sheet metal part manufacture description data.
- ♦ Types of product data supported:
  - (1) Design data for materials, sheet metal in-process parts, sheet metal parts, die components, individual dies, and dies sets;
  - (2) Process data for sheet metal part manufacture;
  - (3) Change and schedule data for design of product definition data and manufacture description data;
  - (4) Data ownership, generating system information, and exchange history surrounding product definition data and manufacture description data;
  - (5) The identification of externally designed parts and purchased items;
  - (6) Design constraints on dies;
  - (7) Wireframe, surface, and solid geometry;
  - (8) Data describing the relative position of materials and in-process sheet metal parts to the die or dies that will further form them;
  - (9) Composition of materials, sheet metal parts, and die components;
  - (10) Properties associated with materials or with collections of geometric representations, such as hardness, porosity, method of manufacture, and function.

- ♦ Stages in the product life cycle supported are data at any stage of completion that describes:

(1) Materials;
(2) Sheet metal in-process parts and sheet metal parts;
(3) Die components, individual dies, and die sets;
(4) Sheet metal part manufacture description data;
(5) Change and schedule data for design of product definition data and manufacture description data.

- The supported exchange scenarios from contractor to supplier are as follows:
  (1) Requirements to enable the supplier to create a sheet metal part processing plan for the contractor, such as the sheet metal part design, available presses and plants, and plant and press constraints;
  (2) Requirements to enable the supplier to create a die design for the contractor, such as the sheet metal part design and the sheet metal part processing plan. This design may be for the die face, or for the die structure, or for both;
  (3) Exchanges wherein the contractor and supplier are divisions of the same company;
  (4) Exchanges wherein the contractor and supplier are different companies.

- The supported exchange scenarios from supplier to contractor are as follows:
  (1) As part process plan or any portion thereof;
  (2) A complete die design or any portion thereof;
  (3) A die face design or any portion thereof;
  (4) A die structure design or any portion therefore;
  (5) A change request;
  (6) Exchanges wherein the contractor and supplier are divisions of the same company;
  (7) Exchanges wherein the contractor and supplier are different companies.

The following are **outside** the scope of this part of ISO 10303:

- Parts that are not made of sheet metal or are not manufactured by a process involving the use of a die or dies;
- Sheet metal parts that are manufactured by explosive forming or forging;
- The design of devices used to stretch sheet metal over single convex dies, or the rubber bladder or sheet used in hydroforming or trap rubber forming to force sheet metal into a single concave die;
- Parametric or variational geometry models of sheet metal parts, dies, or die components;
- Engineering analysis data of any kind;
- Financial data of any kind;
- Manufacturing process data for sheet metal dies;
- Any exchange uses of data in order to:
  ⇒ enable the initial design of sheet metal parts;
  ⇒ enable the design of checking fixtures;
  ⇒ enable the manufacture of the die.
- Data related to production runs of sheet metal parts."

AP207 has 14 Conformance Classes:

The conformance classes are characterized as follows:

cc 1: Product management (PM) and identification information without shape
cc 2: cc 1 and sheet metal part process plan data without shape
cc 3: cc 1 and shapes represented by topologically bounded wireframe models
cc 4: cc 1 and shapes represented by geometrically bounded wireframe and surface models
cc 5: cc 1 and shapes represented by manifold surface models with topology
cc 6: cc 1 and shapes represented by faceted B-Rep
cc 7: cc 1 and shapes represented by advanced B-Rep
cc 8: cc 1 and shapes represented by constructive solid geometry (CSG)
cc 9: cc 2 and shapes represented by topologically bounded wireframe models
cc 10: cc 2 and shapes represented by geometrically bounded wireframe and surface models
cc 11: cc 2 and shapes represented by manifold surface models with topology
cc 12: cc 2 and shapes represented by faceted B-Rep
cc 13: cc 2 and shapes represented by advanced B-Rep
cc 14: cc 2 and shapes represented by constructive solid geometry (CSG)

2.6.5 AP209: Composite and metallic structural analysis and related design (ISO 10303-209:2001)

"This part of ISO 10303 specifies computer-interpretable composite and metallic structural product definition including their shape, their associated finite element analysis (FEA) model and analysis results, and material properties.

The following are **within** the scope of this part of ISO 10303:

- the definition of composite structural parts;
- the definition of metallic structural parts;
- linear statics finite element analysis;
- the product definition and configuration control information pertaining to the design through analysis stages of a product's development;
- the information relating the part to the adjoining components in an assembly by either explicit or external reference;
- the 2D and 3D models depicting the product shape;
- the five types of geometric and topologic model representations which include:
  (1) wireframe and surface without topology;
  (2) wireframe geometry with topology;
  (3) manifold surfaces with topology;
  (4) faceted boundary representation; and
  (5) advanced boundary representation.

- the representations for design and analysis disciplines and the association of the design, idealized design and finite element node shape representations;
- the association of the constituents of composite and metallic parts with the constituent shape model;
- the depiction of composite laminate tables describing the material, stacking sequence, orientation, and constituents of the composite or a portion of the composite with a defined shape;
- the identification of material specifications from internal and external sources and their properties for a specific operating environment;
- the finite element analysis model, analysis controls, and analysis results information;
- the plane stress and simple plane strain types of linear static finite element structural analyses;
- the 2D vector graphical presentation of:
  (1) finite element model maps ;
  (2) analysis output information displays upon finite element model mesh;
  (3) line drawings which document the part aspects subjected to detail analyses
- the tabular presentation of the analysis assumptions, loadings, and critical locations in finite element and detail analyses performed for the assessment of the margin of safety;
- the administrative information necessary to track the approval and configuration control of the design and analysis of a product at a point in the life cycle when approval and configuration control are necessary;
- a change to a design and an analysis, including information to identify the change, at a point in the life cycle when tracking a change is necessary;
- the identification, when required, of the contract under which a design is developed and an analyses is performed;
- the identification of the security classification of a part.

The following are **outside** the scope of this part of ISO 10303:

- the business information for the management of a design and analysis project;
- the product definition and configuration control information pertaining to any information other than that necessary for design and analysis;
- alternate representation of the information by disciplines outside of design and analysis such as manufacturing;
- the use of constructive solid geometry for the representation of the shape of the product;
- the explicit representation of a bill-of-material;
- the other types of finite element analysis beyond linear statics, such as dynamic and non-linear statics;
- the explicit graphical presentations derivable from design or analysis product representations;
- specification of filament wound structures;
- the composite fabrication process information;
- the product definition of initial or in-process part shapes.

AP209 has 10 Conformance Classes.

"…Support for a particular conformance class requires support of all the elements specified in that class.

Conformance to this part of ISO 10303 requires conformance to at least one of the primary conformance classes 7 through 10.

Classes 2 through 6 are the shape representation conformance classes that may be used for ISO 10303-209. One or more shape representation conformance classes may be selected by an implementation and combined with the primary conformance classes 7 through 10."

The conformance classes are characterized as follows:

cc 1: Support for configuration control without shape information.
cc 2: Support for Class 1 plus shapes represented by non-topological surface and wireframe.
cc 3: Support for Class 1 plus shapes represented by wireframe with topology.
cc 4: Support for Class 1 plus shapes represented by manifold surface with topology.
cc 5: Support for Class 1 plus shapes represented by faceted boundary representation.
cc 6: Support for Class 1 plus shapes represented by advanced boundary representation.
cc 7: Support for material, part composite constituents, composite constituent representation, part laminate table, and zone composite constituents and their representation.
cc 8: Support for Class 7 plus finite element analysis model and analysis report.
cc 9: Support for Classes 7 and 8, plus finite element analysis control.
cc 10: Support for Classes 7, 8 and 9, plus finite element analysis results.

2.6.6 AP210: Electronic assembly, interconnect and packaging design (ISO 10303-210:2001)

"ISO 10303-210 specifies the information requirements for the design of electrical printed circuit assemblies.

The following are **within** the scope of ISO 10303-210:

- ♦ The hierarchical description of the printed circuit assembly (PCA) that identifies the functional objects that are used in the PCA composition;
- ♦ The description of the functional objects that are combinations of one or more parts or functional objects;
- ♦ The configuration management of the functional objects that are being developed concurrently;
- ♦ The configuration management of analytical models that are being developed concurrently;
- ♦ The reference to analytic models that are used to define the behavior of a part or PCA or printed circuit board (PCB);

- The description of the connection among the functional objects, packaged parts, and the requirements for physical interconnection;
- The physical layout of the PCA, including a description of the placement of the parts and their interconnections;
- The description of the bare printed circuit board, including the conductive and non-conductive layers of the board;
- The functional and physical description of parts and components, both printed and packaged including material characteristics and composition;
- The description of the requirements and constraints on the design of the PCA that assure product performance, incorporate quality, and enhance manufacturing process capabilities;
- The configuration management of PCA descriptions;
- The description of PCAs and PCBs to implement various functional domains including, but not limited to, analog, digital, video, RF, and microwave;
- The configuration management of constituent parts that are PCAs and PCBs and are being concurrently developed;
- The allocation of requirements to functional objects, physical objects, and the physical implementation;
- The allocation of requirements from functional objects to their physical implementation;
- The configuration management of documents that contain requirements;
- The association of characteristics to functional objects, parts and components;
- The identification of actual parameters for parts and functional objects;
- The identification of planned parameters for functional objects, PCAs, and PCBs.

The following are **outside** the scope of ISO 10303-210:

- The presentation of the part and the PCA descriptions;
- The process plans for the fabrication of the PCB;
- The classification and categorization of data element types;
- The process plans for the assembly of the PCA;
- The definition and interpretation of external file formats for analytic models
- The management of the process used to design a PCA;
- The management of the manufacture of the parts used by a PCA;
- The administrative procurement and cost data used by an enterprise.

AP210 has 30 Conformance Classes:

The conformance classes are characterized as follows:

cc 1 - Device Functional and Physical Characterization
cc 2 - Interconnect Technology Constraints
cc 3 - Assembly Technology Constraints
cc 4 - Assembly Functional Requirements
cc 5 - Assembly Physical Requirements
cc 6 - Interconnect Functional Requirements

cc 7 - Interconnect Physical Requirements
cc 8 - Assembly Physical Design
cc 9 - Interconnect Design
cc 10 - Interconnect Design (Microwave)
cc 11 - Geometric Dimensioning and Tolerancing
cc 12 - Product Rule
cc 13 - Functional Decomposition
cc 14 - Package Functional and Physical Characterization
cc 15 - Geometrically Bounded Surface Model
cc 16 - Wireframe Model with Topology
cc 17 - Advanced Boundary Representation
cc 18 - Constructive Solid Geometry
cc 19 - Extruded Solid
cc 20 - Geometrically Bounded 2d Wireframe Model
cc 21 - Wireframe 2d Model with Topology
cc 22 - Curve 2d
cc 23 - Basic Curve 2d
cc 24 - Laminate Assembly Design
cc 25 - Connection Zone Based Model Extraction
cc 26 - Functional Specification
cc 27 - Physical Unit Physical Characterization
cc 28 - Packaged Part White Box Model
cc 29 - Printed Part Functional and Physical Characterization
cc 30 - Open Shell Model

Conformance to this part of ISO 10303 requires conformance to one of the following:

- any combination of the conformance classes 1 through 7
- conformance class 8
- any combination of the conformance classes 9, 10, 24
- any combination of the conformance classes 24 through 29
- any combination of the conformance classes 13, 14

Conformance class 12 may be used for ISO 10303-210.

Conformance classes 15 through 23, and class 30, are shape representation conformance classes that may be used for ISO 10303-210.

Conformance to a particular conformance class requires that all AIM entities, types, and associated constraints defined as part of that class be supported.

Conformance to a particular conformance class requires conformance to each conformance class included in that class. All entities specified, either directly or indirectly, by required attributes of the required AIM entities shall be supported.

Conformance to a particular conformance class requires that all ARM constraints for UoFs implemented by this class be supported.

cc 1: Device Functional and Physical Characterization

Device Data includes following information: device black box model, package data, functional data, environmental constraints, performance data, simulation models. Formal encapsulation of external data type definitions is made for parametric data and analysis models. Pin mapping is provided to ensure consistency between device views. Shape, material, technology, tolerance on shape and on parameters, units are included. Shapes included may be categorized according to discipline (e.g. thermal analysis, vibration analysis), and analysis environment (e.g., design, assembly, end-user). Geometric Dimensioning and Tolerancing is included. The functional data includes two distinct data sets: hierarchical functional decomposition into behavioural elements embedded in a network represented at each level by a nodal formulation; collection of device terminals (e.g., connector terminals, printed circuit board interface areas, jumper ends) that implement the functionality of a network node. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 2: Interconnect Technology Constraints

This Data includes all information provided to the design team by fabrication vendors from which may be derived default land and passage definitions, based on the desired yield for fabrication and assembly processes. Typical Data includes minimum annular ring, maximum passage aspect ratio, minimum deposition thickness, maximum terminal size supported for through hole technology class, and other critical material processing properties. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 3: Assembly Technology Constraints

This Data includes all information provided to the design team by assembly vendors from which may be derived constraints on which packages may be selected, mounting arrangements to be specified, permitted mounting areas, clearances, etc. Typical bond shape for each unique assembly process is available. Extensive use of formal encapsulation of external data type definitions is made for parametric data. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 4: Assembly Functional Requirements

This Data includes all information required to specify the behaviour of the assembly, including interface definition. Explicit structural definition is provided for the functional network, including representations of usage view and design view, representations of folded and elaborated network hierarchy. This includes gate allocation information. Explicit allocation of each functional network node to the implementing component is included. Extensive use of formal encapsulation is provided for signal definition, mathematical models, etc. This data includes information required to support embedded components in an interconnect product. Configuration management information and design management information is provided.

cc 5: Assembly Physical Requirements
This Data includes all information provided to the design team that may be represented by shape data, including customer requirements, and technology selected to implement those requirements. Explicit allowed volumetric shape, external connection locations are included. Component grouping, keepout, keepin, etc is included. This data includes information required to support embedded components in an interconnect product. Configuration management information and design management information is provided. Preferred parts and packages may be specified by inclusion in design library. This data includes at least one geometric representation.

cc 6: Interconnect Functional Requirements
This Data includes the device data from conformance class 1 (only the functional device information) specific to an interconnect product (e.g., pcb, substrate, flex board). The functional view of Devices which are fabricated as part of the interconnect product fabrication process (e.g., printed inductors, printed connectors, printed capacitors) are included in the functional definition. Devices which are embedded are considered to be external to the interconnect product since they are not fabricated as part of the product and their shape does not directly contribute to the shape definition of the interconnect product. Configuration management information and design management information is provided.

cc 7: Interconnect Physical Requirements
This Data includes all information related to shape and position requirements. Trace, via and other passage spacing, keepin, keepout, etc. is included. Explicit allowed volumetric shape, required connection locations, material specifications, etc. are included. Those layout items whose placement is driven by thermal considerations or electromagnetic interference may be specified. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 8: Assembly Physical Design
This data includes all data that defines the physical relationships between the components in the assembly. This data includes all the components that exist in the assembly, and specifies those that provide physical interfaces to the next level of assembly. Several types of assembly joint may be specified. Design re-use is explicitly supported with traceability. Complete traceability back to requirements is provided. This data identifies those components that do not meet design requirements. Appropriate elements of Geometric Dimensioning and Tolerancing are provided. This data includes both design view and usage view of the assembly. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 9: Interconnect Design
This data provides functional and physical layout information sufficient to allow manufacture and test of an interconnect. Design re-use is explicitly supported with

traceability. Complete traceability back to requirements is provided. Product connection requirements, shape requirements, product specifications, process specifications, material specifications including manufacturing view of stackup, Geometric Dimensioning and Tolerancing are provided. This data identifies those elements that do not meet design requirements. This data includes both design view and usage view of the interconnect product. Support for specification of signal prioritization is provided. Support for specifying the explicit network topology to be implemented is provided. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 10: Interconnect Design (Microwave)
This data is similar to Class 9, with the exception that the metallization may be considered to be microstrip or stripline, with a specified shape element of the cross-section(i.e., point, edge, cutting plane) acting as the terminal(terminal pair, port) of the line or component. Use of formal external definitions is provided to link in models with the product definition data. Analytical model terminals may be distributed. This data identifies those elements that do not meet design requirements. This data includes both design view and usage view of the interconnect product. Support for specification of signal prioritization is provided. Support for specifying the explicit network topology to be implemented is provided. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 11: Geometric Dimensioning and Tolerancing
This data includes the 14 geometric tolerances in ISO 1101. Angularity, circularity, circular run-out, concentricity, cylindricity, flatness, parallelism, perpendicularity, position, profile of any line, profile of any surface, straightness, symmetry, and total run-out. This data includes dimension, limits and fits. This data includes datum system definition. This data includes the tolerance zones in ISO 1101 and ASME Y14.5.(e.g., cylindrical, parallelepiped, projected, and conical). Configuration management information and design management information is provided.

cc 12: Product Rule
This data includes support for rule creation, management, assignment to product data or features, assignment to product or requirement parameters. Complete specification of this capability is deferred until the expression work integration is completed. Configuration management information and design management information is provided.

cc 13: Functional Decomposition
This data includes specification of the folded and unfolded (elaborated) hierarchical product definition in the functional view. Support is provided for a usage view and a design view. The ability to exchange data defining a functional test bench and functional specification based on signals is included. Signal definition relies on external definition, but signal properties may be represented. Support is provided for both lumped element and distributed port properties. Analysis models may be included in the exchange

structure with close integration accomplished by pin mapping. Configuration management information and design management information is provided.

cc 14: Package Functional and Physical Characterization
Package Data includes following information: Case style, material identification, environmental constraints, performance data, simulation models. Formal encapsulation of external data type definitions is made for parametric data and analysis models. Terminal identification is provided to ensure consistency between device views. Package body material is included. Terminals may have core and surface materials. Shape, material, technology, tolerance on shape and on parameters, units are included. Shapes included may be categorized according to discipline (e.g, thermal analysis, vibration analysis), and analysis environment (e.g., assembly, end-user). Geometric Dimensioning and Tolerancing is included. Complex packages may be treated by the design owner as an interconnect product and publish the information in package as the customer view. Formal Reference information to a defining document is provided. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 15: Geometrically Bounded Surface Model
This class shall not be implemented by itself.

- The class requires the implementation of the following Units of Functionality:
- geometrically_bounded_2d_wireframe
- non_topological_surface

cc 16: Wireframe Model With Topology
This class shall not be implemented by itself.

- The class requires the implementation of the following Units of Functionality:
- wireframe_2d_model_with_topology
- wireframe_with_topology

cc 17: Advanced Boundary Representation
This class shall not be implemented by itself.

- The class requires the implementation of the following Units of Functionality:
- advanced_boundary_representation

cc 18: Constructive Solid Geometry
This class shall not be implemented by itself.

- The class requires the implementation of the following Units of Functionality:
- constructive_solid_geometry

cc 19: Extruded Solid
This class shall not be implemented by itself.

- The class requires the implementation of the following Units of Functionality:
- solid_of_linear_extrusion

cc 20: Geometrically Bounded 2d Wireframe Model

This class shall not be implemented by itself.

cc 21: Wireframe 2d Model With Topology
This class shall not be implemented by itself.

cc 22: Curve 2d
This class shall not be implemented by itself.

cc 23: Basic Curve 2d
Includes Only Lines, Circle and Arc Subtype of Conic. This class shall not be implemented by itself.

cc 24: Laminate Assembly Design
This data provides physical assembly information sufficient to allow communication of the arrangement of laminates in an interconnect product, and required interconnections among the materials assembled. Configuration management information and design management information is provided.

cc 25: Connection Zone Based Model Extraction
This data provides information sufficient to allow communication of the explicit geometric basis for connection points of analysis models. Configuration management information and design management information is provided.

cc 26: Functional Specification
This data provides information sufficient to allow communication of the behavioural specification of product functions. Formal encapsulation of external data type definitions is made for parametric data and signal characterization. Configuration management information and design management information is provided.

cc 27: Physical Unit Physical Characterization
Physical Unit Physical Characterization data includes following information: Material identification, environmental constraints, performance data, simulation models. Formal encapsulation of external data type definitions is made for parametric data and analysis models. Shape, material, technology, tolerance on shape and on parameters, units are included. Shapes included may be categorized according to discipline (e.g, thermal analysis, vibration analysis), and analysis environment (e.g., assembly, end-user). Geometric Dimensioning and Tolerancing is included. A Formal Reference capability to the defining document is provided. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 28: Packaged Part White Box Model
Packaged Part White Box Model Data includes following information: device model, package data, functional data, environmental constraints, performance data, and simulation models. Assembly arrangement of devices included in the package to compose the packaged part is explicitly provided. Mapping of analysis model connection points to

package terminals is provided. Formal encapsulation of external data type definitions is made for parametric data and analysis models. Pin mapping is provided to ensure consistency between device views. Shape, material, technology, tolerance on shape and on parameters, units are included. Shapes included may be categorized according to discipline (e.g. thermal analysis, vibration analysis), and analysis environment (e.g., design, assembly, end-user). Geometric Dimensioning and Tolerancing is included. The functional data includes two distinct data sets: hierarchical functional decomposition into behavioural elements embedded in a network represented at each level by a nodal formulation; collection of device terminals (e.g., connector terminals, printed circuit board interface areas, jumper ends) that implement the functionality of a network node. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 29: Printed Part Functional and Physical Characterization
Printed Part Data includes following information: device model, layout template data, functional data, environmental constraints, performance data, simulation models. Mapping of analysis model connection points to printed part terminals is provided. Formal encapsulation of external data type definitions is made for parametric data and analysis models. Pin mapping is provided to ensure consistency between device views. Shape, material, technology, tolerance on shape and on parameters, units are included. Shapes included may be categorized according to discipline (e.g. thermal analysis, vibration analysis), and analysis environment (e.g., design, assembly, end-user). Geometric Dimensioning and Tolerancing is included. The functional data includes two distinct data sets: hierarchical functional decomposition into behavioural elements embedded in a network represented at each level by a nodal formulation; collection of device terminals that implement the functionality of a network node. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 30: Open Shell Model
This class shall not be implemented by itself.

- The class requires the implementation of the following AIM entities:
- manifold_surface_shape_representation

2.6.7 AP212: Electrotechnical design and installation (ISO 10303-212:2001)

This Part of ISO 10303 specifies information requirements for the exchange of design information of electrotechnical plants and industrial systems.

There is no restriction whether those systems are used to equip a building, a plant, or transportation systems like cars or ships. This covers equipment for power-transmission, power-distribution, and power-generation, electrical machinery, electric light and heat, control and automation systems.

This Application protocol includes the description of the data needed for design, installation and commissioning of electrotechnical plants, and for their representation in documents, as specified in IEC 1082: Preparation of documents used in electrotechnology. That includes the hierarchical structure of products and functions, their interrelations, their connectivity and their schematic representation.

The following are **within** the scope of this Part of ISO 10303.

- The data needed to describe an electrotechnical plant throughout the phases of design, installation and delivery although those data will be used throughout the life cycle of the product;
- Data needed to describe terminals and interfaces of electrotechnical products;
- Data needed to describe the functional decomposition of an electrotechnical product;
- Data needed to describe the cabling and harnesses of devices and equipment;
- Data needed to describe cable tracks and to give the required mounting instructions;
- Data needed for the reference designation of the design's building blocks;
- Data needed to specify the pieces of information exchanged between the various parts of the design;
- Objects to furnish the design with appropriate technical data;
- Data that are necessary for the tracking of a design's release;
- Data that are necessary to track the approval of a design or a design aspect.

The following are **outside** the scope of this Part of ISO 10303.

- Data describing design changes before the initial approval (e.g. design corrections from checking);
- The business data for the management of a design project (e.g. budget, schedule);
- Data needed for the simulation and testing of a design (e.g. test patterns, behavioural models);
- The mechanical design of electric/electronic products.

AP212 has 4 Conformance Classes:

The conformance classes are characterized as follows:

cc 1: Configuration Controlled Design and Documentation

This conformance class supports the following areas:

- "classification and item designation;
- configuration controlled design
- documentation using two-dimensional schematic diagrams;
- product oriented connectivity;
- product structure;
- work flow related information.

This conformance class describes the equipment used in an electrotechnical system and its documentation throughout all stages of the design of the system and its installation."

cc 2: Functional Aspects and Information Flow

This conformance class supports the following areas in addition to the content of CC1:

- "allocation of the functional aspects to the physical aspects of the design;
- functional aspects of the electrotechnical system;
- functional networks;
- information flow in the electrotechnical system.

This conformance class describes the functional aspects of an electrotechnical system throughout all stages of the design of the system and its installation."

cc 3: Installation and Arrangement of Electrotechnical Equipment

This conformance class supports the following areas in addition to the content of CC1:

- "documentation using two-dimensional dimensioned drawings;
- information related to the arrangement and positioning of the equipment;
- installation of the system.

This conformance class describes the spatial aspects of an electrotechnical system throughout all stages of the design of the system and its installation and its documentation."

cc 4: Description of the Entire Electrotechnical System

This conformance class supports the information content of cc 1 to cc 3.

This conformance class provides information about all aspects of an electrotechnical systems throughout its design and installation.

2.6.8 AP214: Core data for automotive mechanical design processes (ISO 10303-214:2001)

"The AP Scope - the exchange of information between various applications which support the development process of a vehicle.

The following are **within** the scope of this part of ISO-10303:

- Products of automotive manufacturers and suppliers that include parts, assemblies of parts, tools, and assemblies of tools. The parts include the constituents of the car body, power train, chassis, and interior. (The tools include those specific to the product produced and used by various manufacturing technologies, such as shaping, transforming, separating, coating, or fitting; Typical technologies for primary shaping are molding or casting, for transforming are bending or stamping, for separating are milling or lathing, for coating are painting or surface coating, and for fitting are welding or riveting);
- Process plan information to manage the relationships among parts and the tools used to manufacture them and to manage the relationships between intermediate stages of parts or tools, referred to as in-process parts;
- Product definition data and configuration control data pertaining to the design phase of a product's development;
- Changes of a design, including tracking of the versions of a product and data related to the documentation of the change process;
- Management of alternate representations of parts and tools during the design phase;
- Identification of standard parts based on international, national, or industrial standards and library parts, based on company or project conventions.
- Release and approval data for various kinds of product data;
- Data that identify the supplier of a product and any related contract information;

- Any of eight types of representation of the shape of a part or tool:
  - ⇒ 2D-wireframe representation;
  - ⇒ 3D-wireframe representation;
  - ⇒ geometrically bounded surface representation;
  - ⇒ topologically bounded surface representation;
  - ⇒ faceted-boundary representation;
  - ⇒ boundary representation;
  - ⇒ compound shape representation;
  - ⇒ constructive solid geometry representation.
- Shape representation of parts or tools that is a mixture of the types of shape representation given above (hybrid model);
- Data that pertains to the presentation of the shape of the product;
- Representation of portions of the shape of a part or a tool by form features;
- Product documentation represented by explicit and associative draughting;
- References to product documentation represented in a form or format other than that specified by ISO 10303 (Other forms or formats may be physical clay models, digital data in other standard formats such as NC-data according to ISO 6983, or text data according to ISO/IEC 8879 Standard Generalized Mark-up Language (SGML));
- The simulation data for the description of kinematic structures and configurations of discrete tasks;
- Kinematics simulation of a windshield wiper.
- Properties of parts or tools;
- Surface conditions;
- Tolerance data.

The following are **outside** the scope of this part of ISO 10303:

- Product definition data pertaining to any life cycle phase of a product not related to design;
- Business or financial data for the management of a design project;
- A general parametric representation of the shape of the part or tool;
- Data describing the pneumatic, hydraulic, electric, or electronic functions of a product;
- Continuous kinematics simulations over time;
- Data describing the input or output of finite element analysis.

AP214 has 20 Conformance Classes

The conformance classes are defined for the following application areas:
-- conformance classes 1 to 5 for CAD/CAM;
-- conformance classes 6 to 10 for product structure and configuration management;
-- conformance classes 11 to 13 for process planning;
-- conformance classes 14 and 15 for feature based design;
-- conformance classes 16 and 17 for simulation and quality control;

-- conformance classes 18 and 19 for configuration control of process planning with 3D digital mockup data exchange and sharing;
-- conformance class 20 for complete data storage and retrieval.

The conformance classes are characterized as follows:

cc 1: Component design with 3D shape representation

This conformance class supports the following areas:

- ♦ component design of car body, power train, chassis, or interior parts;
- ♦ component design of tools.

This conformance class includes requirements that match those defined in the conformance classes 2, 4, 5, and 6 of ISO 10303--203, with the additional requirement for geometric presentation (P1), csg model (G7), and element structure (S2). In the area of configuration control information this conformance class requires product management data (S1), which is a subset of conformance class 1 of ISO 10303--203.

cc 2: Assembly design with 3D shape representation

This conformance class supports the following areas:
-- conceptual design including assembly definitions;
-- mountability examination;
-- packaging layout.

This conformance class includes requirements that match those defined in the conformance classes 2, 4, 5, and 6 of ISO 10303--203, with the additional requirement for geometric presentation (P1), csg model (G7), element structure (S2), and external reference mechanism (E1). In the area of configuration control information this conformance class requires product management data (S1) and item definition structure (S3), which is a subset of conformance class 1 of ISO 10303-203.

cc 3: Component drawings with wireframe or surface shape representation

This conformance class supports the following areas:
-- component drawings or sketches for car body or some interior parts;
-- component drawings or sketches for tools.

This conformance class includes requirements that match those defined in ISO 10303-201, with additional requirements for wireframe model 3d (G2) and connected surface model (G3).

cc 4: Assembly drawings with wireframe, surface or solid shape representation

This conformance class is suitable for use in the following areas:
-- component or assembly drawings for power train, chassis, or interior parts;
-- component or assembly drawings for tools.

This conformance class includes requirements that match those defined in the conformance classes 3, 5, 7, 9, and 10 of ISO 10303--202, with the additional requirement for item definition structure (S3), external reference mechanism (E1), and csg model (G7).

This conformance class includes the requirements as defined for the conformance classes 2 and 3 of this part of ISO 10303.

cc 5: Styling data

This conformance class is suitable for use in the following areas:
-- digital mockup;
-- styling.

cc 6: Product data management (PDM) without shape representation

This conformance class is suitable for use in the following areas:
-- product data management systems that manage CAD models as files;
-- administrative data of parts, assemblies, documents, and models.

This conformance class includes requirements that match those defined in the conformance class 1 of ISO 10303--203.

cc 7: Product data management (PDM) with 3D shape representation

This conformance class supports the following areas:
-- administrative data of parts, assemblies, documents, and models;
-- conceptual design including assembly definitions;
-- mountability examination;
-- packaging layout;
-- data exchange between product data management systems linked to CAD/CAM systems.

This conformance class includes requirements that match those defined in the conformance classes 1, 2, 4, 5, and 6 of ISO 10303--203, with the additional requirement for geometric presentation (P1), csg model (G7), element structure (S2), and external reference mechanism (E1).

This conformance class includes the requirements as defined for the conformance classes 2 and 6 of this part of ISO 10303.

cc 8: Configuration controlled design without shape representation

This conformance class is suitable for use in the following areas:
-- configuration control for power train, chassis, car body, or interior parts;
-- configuration control for tools.

This conformance class includes the requirements as defined for the conformance class 6 of this part of ISO 10303, with the additional requirement for specification control (S7).

cc 9: Configuration controlled design with 3D shape representation

This conformance class supports the following areas:
-- configuration control for power train, chassis, car body, or interior parts;
-- configuration control for tools;
-- administrative and configuration control data of parts, assemblies, documents, and models;
-- product data management systems for control of a large number of product variants.

This conformance class includes requirements that match those defined in the conformance classes 1, 2, 4, 5, and 6 of ISO 10303--203, with the additional requirement for geometric presentation (P1), csg model (G7), element structure (S2), external reference mechanism (E1), and specification control (S7).

This conformance class includes the requirements as defined for the conformance classes 7 and 8 of this part of ISO 10303.

cc 10: Configuration controlled design with shape representation and draughting data

This conformance class supports the following areas:

-- configuration control and assembly drawings for power train, chassis, car body, or interior parts;

-- configuration control and assembly drawings for tools;

-- administrative and configuration control data of parts, assemblies, documents, and models;

-- product data management systems for control of a large number of product variants with links to CAD/CAM systems.

This conformance class includes the requirements as defined for the conformance classes 4 and 9 of this part of ISO 10303.

cc 11: Process planning of components

This conformance class supports process planning for components (piece parts) with shape and draughting data.

This conformance class includes the requirements as defined for the conformance class 1 of this part of ISO 10303, without the requirement for geometrically bounded surface model (G8), and the conformance class 3 of this part of ISO 10303, without the requirement for geometrically bounded surface model (G8), and the conformance class 3 of this part of ISO 10303.

cc 12: Process planning of components with form feature and tolerance data

This conformance class supports process planning data for components (piece parts) with shape, draughting, form feature, tolerance, and surface condition data.

This conformance class includes the requirements as defined for the conformance class 11 of this part of ISO 10303, with the additional requirement for user defined feature (FF1), pre defined feature (FF2), generative featured shape (FF3), surface condition (C1), dimension tolerance (T1), and geometric tolerance (T2).

cc 13: Effectivity controlled process planning of assemblies

This conformance class supports process planning with effectivity control for assemblies with shape, draughting, form feature, tolerance, and surface condition data.

This conformance class includes the requirements as defined for the conformance class 12 of this part of ISO 10303, with the additional requirement for item definition structure (S3) and effectivity (S4).

cc 14: Feature based design

This conformance class supports the following areas:

-- feature based conceptual design for components and assemblies, including manufacturing information such as tolerance and surface condition data;

-- feature based mountability examination.

This conformance class allows for identification of form features on the final shape of a component or of an assembly.

This conformance class includes requirements that match those defined in ISO 10303--

224, with the additional requirement for geometric presentation (P1), wireframe model 3d (G2), connected surface model (G3), faceted b rep model (G4), csg model (G7), external reference mechanism (E1), and surface condition (C1).

This conformance class includes the requirements as defined for the conformance class 2 of this part of ISO 10303,

cc 15: Feature based design with flexible feature placement

This conformance class supports the following areas:

-- feature based conceptual design for components and assemblies, supporting efficient design changes through flexible feature placement;

-- feature based mountability examination.

This conformance class allows for an independent feature definition, e.g. in a feature library, and its usage through placement on the shape of a component or of an assembly.

This conformance class includes the requirements as defined for the conformance class 14 of this part of ISO 10303, with the additional requirement for generative featured shape (FF3).

cc 16: Kinematic simulations for components and assemblies with 3D shape representation

This conformance class supports the following areas:

-- collision detection;

-- support of kinematics modules of CAD systems.

This conformance class includes the requirements as defined for the conformance class
2 of this part of ISO 10303, without the requirement for geometrically bounded surface model (G8) and with the additional requirement for kinematics (K1) and item property (PR1).

cc 17: Measured data

This conformance class supports the following areas:

-- exchange of scanned (measured) data from a measuring system to a CAD/CAM system;

-- quality control.

cc 18: Configuration controlled process planning of components and assemblies with 3D shape representation and kinematic data

cc 19: Configuration controlled process planning of components and assemblies with 3D shape representation including form features and kinematic data

cc 20: Data storage and retrieval systems

This conformance class supports database implementations to store, retrieve, or archive all of the data specified in this part of ISO 10303. Data manipulation functionality as performed in application systems is not expected to be implemented within the scope of this conformance class.

This conformance class includes all requirements as defined for the conformance classes 1 to 19 of this part of ISO 10303.

2.6.9 AP224: Mechanical product definition for process planning using machining features (ISO 10303-224 (Ed 1):1999, ISO 10303-224 (Ed 2):2001)

" This Part of ISO 10303 specifies the information needed to define product data necessary for manufacturing single piece mechanical parts. The product data is based on existing part designs that have their shapes represented by machining features. This part supports digital representation for computer integrated manufacturing.

The following are **within** the scope of this Part of ISO 10303:

- A single mechanical part manufactured by machining processes;
- Products that are to be manufactured by either milling or turning processes;
- Machining features for defining shapes necessary for manufacturing (Note: The machining feature set is defined in this part of ISO 10303);
- Machining features definition items necessary for creating machining form features;
- Customer order administrative data to track receipt of an order for a part to the shop floor, but not including tracking of the order on the shop floor;
- Approval data to authorize the manufacture of a part;
- Requisition administrative data to identify requirements and track the status of materials and equipment needed to manufacture a part;
- Identification of the status of a part work order;
- Track the state of raw stock for documenting the manufacturing history of a part;
- Track the design exception notice of a part (NOTE: The design exception notice relates to discrepancies in the machining features used to describe a part's shape);

The following are **outside** the scope of this Part of ISO 10303:

- Results from process planning;
- Representation of assemblies;
- Representation of composite material parts;
- Representation of sheet metal parts;
- Representation of part pedigree;
- Design features of a part;
- Schedule for completing a work order through the manufacturing process;
- Configuration control."

AP224 has a single Conformance Class:

cc: Feature based process planning and shape represented by advanced B-Rep.

AP224 Edition 2 (ISO 10303-224 (Ed 2)):2001

The scope is extended to address the Representation of Manufactured Assemblies.
The content of AP224 is expanded to include:

- several new machining features (cutout, recess, rib top, and shape profile),
- the enhancement of several existing machining features (planar face, n-gon profile, n-gon base shape, and the addition of a rectangular boss subtype),
- the ability to group features.

Features, dimensions, and tolerances are harmonized with AP214.

AP224 Edition 3 (ISO/PWI 10303-224 (Edition 3)) will expand the scope of AP224 to include Gears.

2.6.10 AP225: Building elements using explicit shape representation (ISO 10303-225:1999)

"This part of ISO 10303 specifies the building element shape, property, and spatial arrangement information requirements for building elements. Such information can be used at all stages of the life cycle of a building, including the design process, construction, and maintenance; the purpose is to enable software application systems in all building and construction industry sectors to exchange building element shape, property, and spatial arrangement information. Building element shape, property, and spatial arrangement information requirements specified in this part support the following activities:

- ⇒ concurrent design processes or building design iterations;
- ⇒ integration of building structure designs with building systems designs to enable design analysis;
- ⇒ building design visualization;
- ⇒ specifications for construction and maintenance; and
- ⇒ analysis and review. (e.g., A design analysis function combines the building structure design with building service systems designs (for systems such as heating, ventilation, and air conditioning (HVAC) and piping) to check for physical clashes of the building structural elements with piping or air conditioning elements.

The following are **<u>within</u>** the scope of this part of ISO 10303:

- ♦ Explicit representation of the 3D shape of building elements (The shape of the building elements are represented explicitly using boundary representation (B-rep) solid models, swept solid models, and constructive solid geometry (CSG) models.);
- ♦ The spatial arrangement of building elements that comprise the assembled building;
- ♦ Building structures that represent physically distinct buildings that are part of a single building complex;
- ♦ Non-structural elements that enclose a building or separate areas within a building;
- ♦ The shape and arrangement of equipment and service elements that provide services to a building;
- ♦ The shape and arrangement of fixtures in a building;
- ♦ Service elements include items such as plumbing, ductwork, and conduits. Equipment includes items such as compressors, furnaces, or water heaters.
- ♦ Fixtures include items such as furniture and installed items like doorknobs.
- ♦ Specification of spaces and levels (Spaces include rooms, accesses, and hallways. Levels include concepts such as floors and mezzanines of a building);
- ♦ The shape of the site on which the building will be erected;
- ♦ Specification of properties of building elements, including material composition;
- ♦ Specification of classification information (Elements may be classified for reasons which include cost analysis, acoustics, or safety);
- ♦ Association of properties and classification information to building elements;
- ♦ Changes to building element shape, property, and spatial arrangement information;
- ♦ Association of approvals with building element shape, property, and spatial arrangement information;
- ♦ As-built record of the building.

The following are **outside** the scope of this part of ISO 10303:

- ♦ 2D shape representation and draughting presentation;
- ♦ The contents of building standards;
- ♦ Implicit representation of building elements through selection of standard parameters;
- ♦ Structural analysis of building structures, including loads, connections, and material properties required for analysis;
- ♦ Thermal analysis of buildings;
- ♦ The assembly process, joining methods, and detailed connectivity of building elements;
- ♦ Building maintenance history, requirements, and instructions;
- ♦ Approval, revision, versioning, and design change histories;
- ♦ Building elements without explicit shape representation;
- ♦ Bills of quantities (Note: In industries other than AEC, bills of quantities are often referred to as bills of material)."

AP225 has 14 Conformance Classes:

The three identified levels of geometric complexity are defined as follows:

- ♦ Faceted - geometric representations composed of lines and planes
- ♦ Elementary - geometric representations composed of faceted elements and the following curves and surfaces: circles, ellipses, hyperbolas, parabolas, b-spline curves, conical surface, cylindrical surface, spherical surface, and toroidal surface
- ♦ Advanced - geometric representation composed of elementary elements and b-spline surfaces

The conformance classes are characterized as follows:

cc 1: Building element and component property, classification, identification, and administration information; building composition and building element spatial arrangement; single level assemblies; and building element and component shape using faceted geometric shape representations.

cc 2: Building element and component property, classification, identification, and administration information; building composition and building element spatial arrangement; single level assemblies; and building element and component shape using faceted shape representations.

Note: *The term "geometric shape representation encompasses both geometric sets and b-reps. Omission of the word "geometric" implies that in addition to geometric sets and b-reps, CSG representations are also included.*

cc 3: Building element and component property, classification, identification, and administration information; building composition and building element spatial arrangement; single level assemblies; building site shape; and building element and component shape using faceted and elementary geometric shape representations.

cc 4: Building element and component property, classification, identification, and administration information; building composition and building element spatial arrangement; single level assemblies; building site shape; and building element and component shape using faceted and elementary shape representations.

cc 5: Building element and component property, classification, identification, and administration information; building composition and building element spatial arrangement; single level assemblies; building site shape; and building element and component shape using faceted, elementary , and advanced geometric shape representations.

cc 6: Same as cc 1 except that it includes multi-level assemblies.

cc 7: Same as cc 2 except that it includes multi-level assemblies.

cc 8: Same as cc 3 except that it includes multi-level assemblies.

cc 9: Same as cc 4 except that it includes multi-level assemblies.

cc 10: Same as cc 5 except that it includes multi-level assemblies.

cc 11: Building composition and arrangement of spaces; spaces and space property, classification, identification, and administrative information; and space shape using faceted and ground face space representations.

cc 12: Building composition and arrangement of spaces; spaces and space property, classification, identification, and administrative information; and space shape using faceted, ground face, and elementary space representations.

cc 13: Building composition and arrangement of spaces; spaces and space property, classification, identification, and administrative information; and space shape using faceted, ground face, elementary, and advanced space representations.

cc 14: Building complex and surrounding grounds shape and position.

2.6.11 AP227: Plant spatial configuration (ISO 10303-227 (Edition 1):2001)

This part of ISO 10303 specifies the use of the integrated resources necessary for the exchange of spatial configuration information of process plants. The spatial configuration information includes the shape, spatial arrangement, and other characteristics of the plant piping systems.

Components of the plant piping system include pipes, fittings, pipe supports, valves, in-line equipment, and instruments. Shape and spatial arrangement information for equipment and non-piping plant systems are also included. The primary life cycle phase intended for this AP is design. Other life cycle phases that can make beneficial use of this data include fabrication, installation, and maintenance of plant piping systems.

The following are **within** the scope of this part of ISO 10303:

- The shape and spatial arrangement of plant systems within the process plant;
- Explicit representation of the 3D shape of plant piping systems;
- Explicit representation of the 3D external shape of plant piping system components and equipment (The representation may include envelope, outline and detailed representations as well as a parametric representation of the external shape);
- The logical configuration of the plant piping system and the relationship of the logical configuration to the planned physical piping system design;
- Basic engineering data as needed for spatial layout and configuration of the plant piping system;

- References to functional requirements of the plant piping system, such as stream data and operational characteristics;
- References to or designation of functional characteristics of piping components and connected equipment;
- The identification, shape, location, and orientation of reserved areas, volumes, and space-occupying elements of a plant that are not part of heating, ventilation, and air conditioning (HVAC), piping, structural, electrical, or instrumentation and controls systems;
- References to specifications, standards, guidelines, or regulations, for the plant piping systems, components, or connected equipment that may specify physical characteristics of the system or component;
- Status of spatial arrangement of piping components, piping components, and connected equipment;
- Connections and connection requirements for piping components and equipment;
- Definition of piping component design data sufficient for the acquisition of the components;
- Change request, approval, notification, verification, tracking of differences between versions of piping system design information, tracking of changes to plant items and attributes of plant items;
- Specification of the chemical composition of the streams carried by the plant piping systems in sufficient detail to evaluate the suitability of piping components for the desired process.

The following are **outside** the scope of this part of ISO 10303:

- 2D schematic representations;
- The contents of specifications, standards, guidelines, or regulations;
- Information required for the assembly and erection of non-piping plant systems or the manufacture of components of these systems;
- Specification of the chemical composition of the streams carried by the plant piping system in sufficient detail for process flow design;
- Process design;
- Plant operating procedures;
- Commercial aspects of procurement procedures;
- Internal design of equipment.

AP227 (Ed 1) has 4 Conformance Classes:

The conformance classes are characterized as follows:

cc 1: Piping System Functional Information

"This conformance class provides piping system functional information. This conformance class contains functional information of the piping system and catalogue reference information, but no shape or spatial information. This conformance class enables … exchange of functional information on plant piping systems. (The purpose of this conformance class is to provide an interface with ISO 10303 - 221 and piping functional design and schematics software.)"

cc 2: Equipment and Component Spatial Information

"This conformance class provides equipment and component spatial information. This conformance class contains basic equipment performance characteristics, connector location and orientation information, material specifications, version information, explicit shape, and catalogue reference information. This conformance class enables the exchange of minimal vendor equipment and component information."

cc 3: Plant Layout and Piping Design Information

"This conformance class provides plant layout and piping design information. This conformance class contains design, layout, and spatial information for the plant, and catalogue reference information. This conformance class enables the exchange of plant layout and piping design information for the following activities:

- Area classification;
- Space analysis;
- Plant arrangement (placement of space occupying elements);
- Spatial design of piping systems including pipe routing and component placement and placement of pipe supports;
- Operation and maintenance analysis;
- Constructability reviews;
- Interference checking;
- Development of equipment list and line list;
- Development of equipment takeoffs;
- Development of material takeoffs for piping and piping components;
- Connectivity and topology checks;
- Material and connection compatibility checks;
- Provision of spatial design information to support fabrication and construction;
- Spool and weld identification;
- Plant startup;
- Plant commissioning;
- Plant operation;
- Configuration management of plant items and piping system information.

Although not explicitly cited above, this conformance class also supports the activities listed for the other conformance classes."

cc 4: Piping Fabrication and Installation Information

"This conformance class provides piping fabrication and installation information. This conformance class contains system, plant item, and line identification, piping information, plant item characteristics and shape, and catalogue reference information. This conformance class enables the exchange of piping fabrication and installation information."

All four conformance classes include information concerning plant item characterization, piping component characterization, connectors, connections, and change information.

Edition 2 of ISO 10303-227 is being balloted as a Committee Draft (CD) from 30 November 2001 to 28 February 2002. It includes ship piping and HVAC, and it replaces AP217.

The Scope of Edition 2 of ISO 10303-227 specifies the use of the integrated resources necessary for the scope and information requirements for the exchange of spatial configuration information of process plants, plant systems and ship systems. The spatial configuration information focuses on the shape and spatial arrangement of the components of the systems. The spatial configuration information principally supports the engineering, fabrication and installation life-cycle phases, but may be useful in the downstream life-cycle phases of operations and maintenance. This part accommodates the disciplines of plant design, system design, fabrication, inspection, installation and construction.

The following additional items are have been added to the scope of Edition 2 of ISO 10303-227:

— the shape and spatial arrangement of items in systems within a process plant or ship;
— information required for the design, analysis, fabrication and installation of piping components and piping systems;
— information on the inspection of fabricated piping; (NOTE: The functional configuration entails connectivity, sequencing, component size, and schedule, and may include other information, such as equipment tag numbers and requirements to perform consistency checks between the functional and physical representations of the design.)
— the identification of catalogue information associated with a component;
— the identification of catalogues that contain component definitions;
— status of components and connected equipment and of their spatial arrangement;
— data exchange;
— external reference to classification systems;
— external reference to standard parts;
— external reference to representations of standard parts.

The following additional items are **<u>outside</u>** the scope of Edition 2 of ISO 10303-227:

— preparation of piping specifications;
— logistics and materials management;
— process design and conceptual engineering (e.g., process material and heat balances, process flow diagram development, and determination of equipment sizes);
— testing, commissioning, handover, maintenance, and disposal of a plant;
— information necessary to manage the evolution and growth of data sets through the life-cycle of a product or project other than indications of changes and approvals;
— history data;
— internal design and maintenance of equipment.

Edition 2 of ISO 10303-227 has added five (5) conformance classes grouped as follows:

Conformance class 1 - Piping system functional information (Same as Edition 1);
Conformance class 2 - Equipment and component spatial information (Same as Edition 1);
Conformance class 3 - Plant layout and piping design information (Same as Edition 1);
Conformance class 4 - Piping fabrication and installation information (Same as Edition 1);

Conformance class 5 - Piping inspection information (New)
This conformance class provides piping inspection information in addition to the piping fabrication and installation information provided in conformance class 4. This conformance class contains system, plant item, and line identification, piping information, plant item characteristics and shape, catalogue reference information, and piping inspection information. This conformance class enables the exchange of piping inspection information in addition to piping fabrication and installation information.

Conformance class 6 - HVAC system functional information (New)
This conformance class provides HVAC system functional information. This conformance class contains functional information of the HVAC system and catalogue reference information, but no shape or spatial information. This conformance class enables the exchange of functional information on heating, ventilation, and air-conditioning (HVAC) systems.

Conformance class 7 - HVAC spatial information (New)
This conformance class provides HVAC layout and design information. This conformance class contains design, layout, and spatial information for the HVAC systems within the plant, and catalogue reference information. This conformance class enables the exchange of HVAC layout and design information and supports the following activities:
— area classification;
— space analysis;
— plant arrangement (placement of space occupying elements);
— spatial design of HVAC systems including component placement;
— HVAC operation and maintenance analysis;
— HVAC constructability reviews;
— interference checking;
— development of HVAC equipment list and line list;
— development of HVAC equipment takeoffs;
— development of material takeoffs for HVAC and HVAC components;
— connectivity and topology checks;
— material and connection compatibility checks;
— provision of spatial design information to support HVAC fabrication and construction.

Conformance class 8 - Cableway spatial information (New)
This conformance class provides cableway spatial information. This conformance class contains layout and spatial information for the cableway systems within the plant. This conformance class enables the exchange of cableway layout and spatial information, but does not provide the details of the cableway contents or the operating characteristics. Details of cableway contents or operating are beyond the scope of this edition of ISO 10303-227.

Conformance class 9 - Piping and HVAC analysis information (New)

This conformance class provides piping and HVAC analysis information. It enables the exchange of sufficient information about a piping or HVAC system for the performance of stress or flow analysis on the receiving system. It does not, however, include exchange of the results of such an analysis.

Options within a conformance class (New)
Several conformance classes have several shape representation options to allow for various geometric representations.

- Option A in any conformance class provides for the exchange of Brep shape representation
- Option B in any conformance class provides for the exchange of Pure CSG shape representation. This includes only primitive CSG solids, excluding swept, extruded, or Brep solids
- Option C in any conformance class provides for the exchange of Hybrid CSG shape representations. These include all CSG solids and Brep solids

The units of functionality for site_characterization and change information are also included as optional within each conformance class.

- Site_characterization, in particular, allows the file to be specified as applying to a "ship" rather than to a traditional "process plant"
- Change information allows revision history to be optionally included in an ISO 10303-227 file for any conformance class

2.6.12 AP232: Technical data packaging core information and exchange (ISO 10303-232:2002)

(On 21 December 2001, the ISO 10303-232 document was submitted to the TC184/SC4 Secretariat for transmission to the ISO Central Secretariat for Publication as an International Standard. Publication is expected in the May/June 2002 time frame)

"This part of ISO 10303 will provide the structure to package/relate groups of product information so that configuration controlled exchanges can be achieved among Product Data Management (PDM) systems. Each group of product information being packaged by this AP may be exchanged in this AP's STEP format, another AP STEP format, or any other format agreed to by the exchanging partners. This capability will satisfy the industrial need to communicate and share the total design definition of a product among originating organization, partners, vendors, and customers. The goal of this application protocol is to provide an information structure where product information can be electronically captured and managed from both a product item perspective and a document based perspective.

Current Product Data Management (PDM) systems being installed in industry still manage documents but from a product view point. Currently no STEP AP addresses a document configuration structure for product data. This AP will deal with filling this document configuration structure void. The consequence of not developing this AP will be that enterprises and industries that have large infrastructures that rely on document based management systems will be reluctant to implement STEP due to a large initial investment they would have to make to change systems and procedures. This AP allows these industries an expedient migration path into STEP and into configuration control of product data from a product item perspective.

There are two aspects to AP 232. The first is the packaging of product data groups. The second is to provide the exchanged requirements of individual product data groups focusing on associated list information such as parts list, data list, index list, indentured data list, and applications list.

The packaging aspect provides the requirements for collecting, organizing, and managing the exchange of a complex set of data files or database views representing the different product data groups that define a product. A product data group defines a particular view of product information and may be identified and managed as a document, or product data set or a unique view within a database. Drawings, Associated lists and Reference Documents are considered product data groups. The result of packaging product data groups is called a Technical Data Package (TDP). As a result of this packaging, AP 232 defines the interoperation of other ISO 10303 Parts (e.g. ISO 10303-203 and ISO 10303-202) and the managed inclusion of a mixed set of standards for representation of the various TDP elements (product data groups)."

AP232 has 14 Conformance Classes:

The conformance classes are characterized as follows:

cc 1: Data definition exchange (DDE) for files;
cc 2: Data definition exchange (DDE) for TDP elements;
cc 3: Data definition exchange (DDE) for indentured methods;
cc 4: Parts list (PL);
cc 5: Data list (DL);
cc 6: Indentured data list (IDL);
cc 7: Index list (IL);
cc 8: Other list (OL);
cc 9: List with presentation (cc 9 shall be implemented with one or more of cc 1 - 8.);
cc 10: Reference document identification and drawing identification;
cc 11: Reference document identification and drawing identification with ISO 10303-201 and ISO 10303-202 drawing presentation identification;
cc 12: Product data set (PDS) without presentation format (includes 3D models with surfaces and solids);
cc 13: Product data set (PDS) with shading (includes conformance class 12 and shading information);
cc 14: Product data set (PDS) with presentation format (includes cc 13, tolerances, annotation, and presentation information for human readability.

cc 11 combines conformance class 10 with the drawing structure and administration capability found in ISO 10303-505.

cc 14 combines the capability of product shape geometry with presentation annotation and tolerances

NOTE: AP232 contains the PDM Schema as a proper subset.

2.7 SCOPES of AP's that are "In Process"

2.7.1 AP204: Mechanical design using boundary representation (ISO/FDIS 10303-204)

(AP204 will have its two (2) month FDIS Ballot during the 1st Quarter of 2002.)
This document describes an application reference environment for the generation and exchange of volume based design data in the Computer Aided Mechanical design process, together with appropriate data models and a physical file implementation form. The information model supports all geometric and topological aspects of a complete description of the shape and size of an object.

It was originally developed for applications in mechanical engineering design using the CAD modelling technique boundary representation (B-rep) solid modelling and may be appropriate for other application areas using this technique.

The following are **within** the scope of this Part of ISO 10303:

- Three types of B-rep model that are used to represent shape:
  a) facetted B-rep model;
  b) B-rep model with elementary surfaces;
  c) B-rep model with sculptured surfaces;
- curve and surface geometry;
- curves defined in parameter space (pcurves);
- manifold topology;
- product identification information;
- the association of simple presentation attributes such as line-style, line-width, colour with a B-rep model or with geometric or topological elements;
- preservation of user-defined names of objects;
- units and measures associated with geometric elements;
- assemblies of parts and sub-assemblies.

The following are **outside** the scope of this Part of ISO 10303:

- Other types of shape representation:
  a) wireframe models;
  b) surface models;
  c) geometrically trimmed curves and surfaces;
  d) constructive solid geometry models;
  e) compound B-rep models.
- Geometric and topological data:
  a) 2D geometry;
  b) self-intersecting geometry;
  c) non-manifold topology.
- Dimensioning;
- Tolerances;
- Manufacturing information;
- Advanced presentation features, such as multiple views, character fonts, symbols;

- Material information;
- Meshing information;
- Analysis models, such as finite element analysis.

2.7.2 AP213: Numerical control process plans for machined parts (ISO/PWI 10303-213)

(AP213 has been inactive since the 1996/1997 timeframe (after completing its DIS Ballot). It has become somewhat “out of date” as new related STEP Application Protocols have evolved. The scope given below represents the original AP213 Scope. During the First Quarter of 2002, AP213 will be reinitiated as a NWI as part of SCRA’s execution of the TACOM N-STEP Project. Proposed changes to the scope/requirements for the “new” AP213 are given at the end of this section. For more detail/discussion, see Documents 14, 15, and 16 in Appendix A.)

This part of ISO 10303 specifies information requirements for the exchange, archival and sharing of computer-interpretable numerical control (NC) process plan information and associated product definition data.

The following are **within** the scope of this part of ISO 10303:

- Information from the planning activity that is contained in the NC process plans for machined parts;
- Work instructions for the tasks required to manufacture a part, using numerical control, which include:
  (1) references to the resource required to perform the work;
  (2) the sequences of the work instructions;
  (3) relationships of the work to the part geometry;
- references to standards and specifications declared in the process plan;
- information required to support NC programming of processes specified in the process plan (This includes product definition, administrative data, machine, tooling, and material requirements);
- Information required to support in-process inspection specified in the process plan (In-process inspection includes such tasks as using gage blocks or performing a probing operation to verify the dimensional constraints placed upon the part);
- shop floor information specified in the process plan (Shop floor information containing such items as part routing, machine setup, and part loading instructions).

The following are **outside** the scope of this part of ISO 10303:

- NC process information derived from, or required for, manufacturing preplanning activities (This includes information from activities such as factory capacity planning , scheduling, producibility analysis, and statistical process control);
- production control and scheduling analysis;
- production planning functions;
- actual execution of the process plan;
- continuous processes (Continuous process is the control of a process that requires feedback to determine new parameters such as those used in the manufacture of chemical and plating products);

- make or buy analysis activities;
- costing data;
- NC program, source programs, and specific machine tool controller codes;
- form features;
- drawing and production illustration contents;
- the process planning activity itself;
- inspection processes that require an inspection plan (Inspection processes refer to inspection that occurs outside the context of the NC machining process, such as removing the part and remounting it on a Coordinate Measuring Machine (CMM)).

AP213 has 6 Conformance Classes

The conformance classes are characterized as follows:

cc 1: NC process plan information without shape;
cc 2: cc 1 and shapes represented by non topological surface and wireframe models;
cc 3: cc 1 and shapes represented by wireframe models with topology;
cc 4: cc 1 and shapes represented by manifold surface models with topology;
cc 5: cc 1 and shapes represented by faceted b-rep;
cc 6: cc 1 and shapes represented by advanced b-rep.

cc 1 is a prerequisite for cc 2 through 6. If an implementation conforms to any of cc 2 through 6, then it shall also conform to cc 1.

NOTE: This AP will be re-initiated as a NWI in the Second Quarter of 2002 as a part of TACOM's N-STEP Project. The scope will be updated to be feature based and harmonized with other STEP AP's such as AP224 and AP214 and the evolving AP219 and AP238 as well as the ISO 14649 series of standards for Numerical Control Processors. It is anticipated that AP213 will be "fast tracked" through the ISO process. (See 2.8.1)

The following are proposed changes to AP213:

1. Enhance 'NC part object elements' to also include AP224 machining features developed in design. This gives the process planning activities the 'as designed' data in a more granular format.
2. Enhance 'Material removal' activity' to be sub-typed to more granular activities. With the AP224 machining features being used by AP213, the material removal activity can be made more specific. For example AP213 could define activities for "mill pocket", "bore hole", "plane part face", etc. The addition of machining features will increase the intelligence added to the process activity.
3. Enhance the support of both dimensional and geometric tolerances, again harmonization with the AP224 data that is input to process planning is required.
4. Enhance the validation activity to support tolerances. Currently this activity is given geometry to be used for in process inspection, but the geometry contains no intelligent tolerance information, and AP213 can not completely define 'in process inspection'. If AP213 is enhanced with the AP224 tolerances the validation activity can be enhanced to support in process inspection. The validation activity can be sub typed into more specific

activities such as: inspection activity, in line quality assurance, or in process gauging activities.

5. Enhance the reference to 'NC program' to support ISO 14649. Currently AP213 references ISO 6983 files to define the NC program. This is the traditional "M" and "G" code standard. However there are soon to be new machine controllers that will support the new STEP style input. These new machine tools will be using the ISO 14649 standard, which no longer defines an NC program but rather an NC workplan. AP213 needs to be able to reference this new standard as well as support the existing ISO 6983.
6. Enhance AP213 to support the 2nd edition STEP Integrated Resource (IR) parts and to harmonize with the product data model. To promote interoperability among application protocols, a naming convention of applied_xxx_assignment is being used by a number of application protocols, wherein xxx is the unique part of the abstract management resources entity name. Further enhancements would be to investigate the use of STEP modules to support common requirements between APs.

2.7.3 AP215: Ship arrangement (ISO/CD 10303-215)

(AP215 will be balloted as a DIS in the Second Quarter of 2002)

This part of ISO 10303 specifies the use of the integrated resources necessary for the scope and information requirements for the exchange of three-dimensional product definition data and its configuration status information for Naval and commercial ship arrangements. Configuration in this context pertains to data specific to revision tracking and change history of selected ship spatial entities within the Product model. The term exchange is used to narrow the scope to only those data that are transferred between enterprise systems. This is to distinguish it from a data model supporting distributed, multi-user database applications.

The following are **within** the scope of this part of ISO 10303:

- ♦ data describing the general subdivision of a ship into spatially bounded regions;
- ♦ data identifying physical boundaries partitioning the ship into compartments suitable for the stowage of cargo, operation of machinery, and occupancy by crew and passengers;
- ♦ data identifying logical boundaries subdividing the ship into zones for the purpose of controlling access, designating design authority, or applying specific design requirements;
- ♦ data required for the definition of spatial boundaries based on references to moulded form regions or geometric surfaces;
- ♦ configuration management data for identification of versions of compartment designs and for management of changes to the design during the design life cycle phase;
- ♦ data identifying the intended functions of compartments and zones;
- ♦ data required for recording the volumetric capacities of cargo compartments at various combinations of vessel heel and vessel trim;
- ♦ data required for calculation of the magnitude and location of loads acting upon a ship's structural systems due to the weight of cargos contained in compartments;
- ♦ data required for the determination of adjacency of compartments;

- data identifying spaces related by common functional purpose, position within the ship, or connection by engineering systems;
  EXAMPLE: Port and starboard wing tank pairs are spaces related by position.
- data identifying dimensional aspects of spaces;
- data identifying the product structuring of engineering parts and structural parts contained within a space;
- data identifying the product structuring of compartments in an area the ship;
- data required for the definition of design requirements placed on a space by systems within the ship;
- data required for the identification of cargos, stores and consumables and allocation of those items to compartments and tanks for design analysis or on specific voyages during the operation of the ship;
- definition of loading conditions for analysis of the floating position of the ship under different cargo loading scenarios;
- data required for the analysis of stability of the ship after damage.
  NOTE 2: Annex L provides additional information pertaining to the industrial use of this part of ISO 10303.

The following are **outside** the scope of this part of ISO 10303:
- data defining the representation of moulded surfaces of structural or non-structural bulkheads;
  NOTE 3: Moulded forms are referenced by external instance references to 10303-216.
- data defining the representation of structural systems and parts.
  NOTE 4: Structural systems and parts are referenced by external instance references to 10303-218.

ISO/DIS 10303-215 has the following conformance classes:
- Class 1 is a conformance class to exchange early design data regarding ship arrangements;
- Class 2 is a conformance class to exchange detail design data regarding ship arrangements;
- Class 3 is a conformance class to exchange operational data regarding ship arrangements;
- Class 4 is a conformance class to exchange analysis data regarding ship arrangements.

Support for a particular conformance class requires support of all the options specified in that class. Conformance to a particular class requires that all of the AIM elements defined in Clause 6 as part of that class be supported.

2.7.4 AP216: Ship moulded forms (ISO/DIS 10303-216)

(AP216's five (5) month DIS Ballot period started on 29 November 2001 and ends on 29 April 2002.)

This part of ISO 10303 specifies the scope and information requirements for the exchange of ship moulded form definitions, geometric representations, and related hydrostatic properties.

The following are **within** the scope of this part of ISO 10303:

- definition of moulded form geometry related to commercial and naval ships;
- definition of moulded form geometry of the preliminary design, detailed design, and production stages of the life cycle of a ship;
- definition of moulded form geometry that describe the hull moulded form of the ship, including mono hullforms, multi-hullforms, the bulbous bow, transom stern, thruster tunnels, and additional appendages; (**EXAMPLE:** Types of moulded form geometry are bilge keel, spray rails, shaft struts, and shaft bossings that are part of the final moulded form of the ship hull.)
- definition of moulded form geometry that describe the moulded form of propellers and rudders;
- definition of moulded geometry that describe the moulded form of decks including camber and sheer;
- definition of moulded geometry of internal ship compartment boundaries and the moulded form geometry of ship structural and non-structural elements; (**EXAMPLE**: Bulkheads, girders, and profiles are examples of moulded form geometry of ship structural elements.)
- definition of general characteristics; (**EXAMPLE**: Main dimensions, ship type, shipyard, ship owner, and classification data are examples of general characteristics.)
- definition of design parameters for the ship hull, bulbous bow, propeller, rudder, and appendages that are necessary to describe the moulded form, and are required to calculate hydrostatic properties;
- definition of hydrostatic properties of the ship moulded form that depend on the draught of the ship; (**EXAMPLE:** Displacement, centre of buoyancy, centre of flotation, metacentric height, and cross curves of stability are examples of hydrostatic properties.)
- definition of global and local co-ordinate systems and spacing tables used in naval architecture for position purposes;
- shape definition of ship moulded forms that use one of the following specified types of geometric representation:
- offset table representation;
- wireframe representation;
- surface representation.
- geometric representations containing geometric elements used in naval architecture; (**EXAMPLE**: Waterlines and buttock lines are examples of geometric representations.)
- version control and approval of moulded forms and related hydrostatics.

The following are **outside** the scope of this part of ISO 10303:

- product definition data related to hull plating defined on the moulded form;
- product definition data related to ship compartmentation and ship arrangements; (**NOTE**: Reference ISO 10303-215).
- product definition data related to ship structures and ship assemblies; (**NOTE:** Reference ISO 10303-218).

- product definition data related to ship machinery and ship superstructures; (**NOTE**: Reference ISO 10303-226).
- mechanical systems and material aspects of propellers, rudders and control surfaces; (**NOTE**: Reference ISO 10303-226).
- product definition data from the decommissioning stage of the ship life cycle;
- hydromechanic properties of the ship; (**EXAMPLE**: Motion response and ship maneuvering are examples of hydromechanic properties.)
- damage stability properties of ships;
(**NOTE**: Reference compartmentation damage stability properties of ISO 10303-215.)
- ship longitudinal strength.

AP216 has the following conformance classes:

- Class 1 is a conformance class to exchange hydrostatic data;
- Class 2 is a conformance class to exchange moulded form geometry as an offset table;
- Class 3 is a conformance class to exchange moulded form geometry as a wireframe representation;
- Class 4 is a conformance class to exchange moulded form geometry as a surface representation;
- Class 5 is a conformance class to exchange moulded form geometry as a surface representation with hull applicability;

Conformance to a particular class requires that all of the AIM elements defined in Clause 6 as part of that class be supported.

2.7.5 AP218: Ship structures (ISO/CD 10303-218)

(AP218 will be balloted as a DIS during the Second Quarter of 2002.)

This part of ISO 10303 specifies the use of the integrated resources necessary for the scope and information requirements for the exchange of product definition data and its configuration and approval status information for ship structural systems. Configuration in this context pertains to data specific to revision tracking and change history of selected ship structural entities within the product model. Approval pertains to the company internal approval and the classification society approval. This Application Protocol supports the shipbuilding activities and applications associated with the design phase and the manufacturing phase.

The following are **within** the scope of this part of ISO 10303:

- product definition data pertaining to the ship's structure which includes hull structure, superstructure and all other internal structures of commercial and naval ships;
- product definition data pertaining to the ship's structure
- product definition data pertaining to the pre-design phase of the ship's structure;
- product definition data pertaining to the main design phase of the ship's structure;
- product definition data pertaining to the manufacturing phase of the ship's structure;
- product definition data pertaining to the product structuring of ships, including the structuring by system and by assemblies within the ship;

- product definition data identifying the ship's general characteristics which are relevant to the design of the ship's structure; (**NOTE:** The general characteristics include ship's main dimensions, designations and principle characteristics, as well as the rules, regulations and standards applicable to the ship. It also includes lightships weight distribution and free-board characteristics for the purpose of design and design approvals.)
- product definition data pertaining to the ship's global co-ordinate system, local co-ordinate systems and spacing grids, which are used for defining the geometry of the ship's structure;
- product definition data pertaining to the geometrical representation of the ship's structure parts and assemblies;
- product definition data pertaining to the hull plating and the stiffener profiles, and the definition of structural features, which comprise the ship's structure parts and assemblies, including functional descriptions; (**EXAMPLES**: edge, corner and interior cut-outs are structural features.)
- product definition data pertaining to the design of the welded connections and joints of ship's structure parts and assemblies, including edge preparations and weld type and size;
- product definition data pertaining to the specification of transverse cross-sections through the ship's structure for the purpose of approval of strength;
- product definition data pertaining to ship's design loads, including shear forces and bending moments acting on the ship's structure, for the purpose of determining the longitudinal strength of the ship;
- product definition data pertaining to the weights and centres of gravity of the ship's structure parts and assemblies;
- product definition data pertaining to the materials of ship's structure, required to manufacture the ship or a part of it;
- product definition data pertaining to the configuration management of the ship's structure, including approval, versioning and change administration;
- product definition data pertaining to external references, technical documentation and other supporting concepts which are necessary and pertinent to the design and manufacture of the ship's structure parts and assemblies.

The following are **outside** the scope of this part of ISO 10303:

- product definition data pertaining to the ship's structure at the operation and de-commissioning phases of the ship's life cycle;
- business data for the management of a ship development project, such as budgets, schedules and resource requirements;
- product definition data pertaining to the direct calculation of ship's structure in the design stage;
- product definition data pertaining to the coating of structural parts as well as the production tolerances;
- product definition data pertaining to the ship's subdivision;
- product definition data pertaining to the ship's distribution systems; (**EXAMPLES**: The electrical, piping and HVAC systems)

- product definition data pertaining to the ship's machinery and propulsion systems;
- product definition data pertaining to the ship's outfit and furnishing;
- product definition data pertaining to ship's hull structure parts which are manufactured by forging or casting. (**EXAMPLES**: Stern frames, rudder horns and propeller shaft brackets)

AP218 has the following conformance classes:

Each conformance class grouping has been further qualified by a specific geometry option, indicating that representations of the data that will be created with the given AIC geometry.

Option A – Edge based wire frame representation
Option B – Geometrically bounded wire frame representation
Option C – Non-manifold surface shape representation
Option D – Advanced boundary representation
and
Option H – Hull Applicability

If a geometry option is not specified, it is assumed that either no representation is present or that it is defined implicitly by the optional parameters on design_definition.

- Classes 1 – 3: ship structures definition and approval data that is created at the preliminary design stage of a ship, has structural definitions and shape representations of this stage, shall be exchanged between the shipyard and the subcontractor; and, the early class approval data for the preliminary design of the ship, including the definition of hull cross sections, has class approvals with regard to the detailed design definitions, shall be exchanged between the subcontractor and shipyard, and between the shipyard and the classification society;
  - Class 1 has Option A
  - Class 2 has Option C
  - Class 3 has Options C & H

- Classes 4 – 6: ship structures definition and approval data that is elaborated at the detailed design stage of a ship, under consideration of the production design of ship structures, shall be exchanged between the shipyard and the subcontractor;
  - Class 4 has Option D
  - Class 5 has Option C
  - Class 6 has Options C, D & H

- Classes 7 – 13: ship structures definition and approval data that is completed at the product manufacturing stage of a ship, has manufacturing and welding definitions, shall be exchanged between the design department and the manufacturing department of the shipyard;
  - Class 7 has Option A
  - Class 8 has Options A & H
  - Class 9 has Options C

- ➢ Class 10 has Options C & H
- ➢ Class 11 has Option B
- ➢ Class 12 has Option D
- ➢ Class 13 has Options D & H

♦ Classes 14 – 15: class approval data for the structural parts (plates and profiles) of the ship, has class approvals with regard to the manufacturing definitions, shall be exchanged between the shipyard and the classification society.
- ➢ Class 14 has Option C
- ➢ Class 15 has Options C & H

Conformance to a particular class requires that all of the AIM elements defined in Clause 6 as part of that class be supported.

.

2.7.6 AP219: Manage dimensional inspection of solid parts or assemblies (ISO/PWI 10303-219)

(AP219 has been formulated as a Preliminary Work Item (PWI), but has not yet been balloted as a New Work Item (NWI).)

"This application protocol will specify information requirements to manage dimensional inspection of solid parts or assemblies, which includes administering, planning, and executing dimensional inspection as well as analysing and archiving the results. Dimensional inspection can occur at any stage of the life cycle of a product where checking for conformance with a design specification is required.

The following are excluded from the scope of AP219:
- ♦ Developing or modifying manufacturing process information*
- ♦ Generating geometry (creating the CAD model)*
- ♦ Generating tolerance requirements*
- ♦ Inspection of material properties

* These activities are considered out of scope, but the information resulting from these activities may be used by the Application Protocol."

2.7.7 AP220: Process planning, manufacturing, assembly of layered electrical products (ISO/PWI 10303-220)

(AP220 has been inactive. It is anticipated that it will be re-initiated in 2002 or 2003.)

This STEP AP covers both printed-circuit boards (PCBs) and printed-circuit assemblies (PCAs), which are the unpopulated and populated objects often referred to as bare and assembled boards. The AP shall cover the PCB and PCA product data, which is shared between the manufacturing engineering and the production operation. The scope of this AP includes the information required to describe the functional capabilities of the equipment in a manufacturing facility and the process plan for producing the product in a specific facility or facilities.

2.7.8 AP221: Functional data and their schematic representation for process plants (ISO/CD 10303-221)

(See 2.8.3 also) (This AP has been inactive. The CD was balloted in 1997. It will be reinitiated as a NWI during the 1st Quarter of 2002, and it is expected to be balloted as a modularized DIS later in 2002.)

This AP considers the representation and exchange of process-plant functional data and its 2D schematic representation. The types of plant considered includes power generation (nuclear and conventional), chemical and petroleum plants. The AP is limited to the design phase in the life cycle of a process plant. However the data contained within the model is capable of transfer forward to the later phases.

The core of the functional data is the identification and description of the equipment and components within the plant. This data provides the continuity between design, construction and operation phases of the process plant life cycle. The functional data may define the decomposition of the set of equipment and components into systems and sub-systems, and may specify connectivity.

This AP also considers the information associated with functional data necessary to enable its display as a 2D schematic; i.e., a Piping & Instrumentation (P and I) Diagram.

The AP considers P and I, and **will include**:

- the connectivity of equipment, piping and control devices;
- pipeline designation (line number) and design specification (material, dimensions, insulation and paint specification);
- the direction of fluid flow through piping;
- equipment (e.g., column, heat exchanger, reactor, pump and vessel) identification and design specification;
- piping components (e.g., flange, valve, tee gasket, etc.) identification and design specification;
- control-loop designation;
- control-loop component (e.g., instrument, transmitter, controller) identification and design specification;
- general information about the project, such as identification, location, contract, etc.

The following is a description of the detailed scope and conformance classes for the modularized version of AP221. (**See**: http://www.uspi.nl)

"This part of ISO 10303 specifies the application protocol for the exchange of Functional data and their schematic representation for process plants. Functional data includes the functional design of systems, and the engineering specifications of system components to be used for subsequent procurement or component design.

The following are **within** the scope of this part of ISO 10303:

- Functional data about a physical object within a process plant;
  Functional data includes:
  - identification;
  - decomposition structures;
  - connectivity;
  - classification; and
  - properties.

  Functional data can be about:
  - the whole lifetime of the physical object;
  - a state, mode of operation, or design case for a physical object; or
  - a segment in the life of a physical object, with a start and end time.

  A physical object within a process plant can be:
  - a system;
  - a plant item;
  - a component of a system or of a plant item;
  - a batch of process or utility material;
  - a stream of process or utility material.

  Systems within scope include:
  - systems that handle process materials and utility materials;
  - auxiliary systems for equipment;
  - process control and monitoring systems;
  - safety, health and environmental control and monitoring systems;
  - electrical power generation, transmission and distribution systems with a process plant.

  Plant items and components within scope include:
  - process equipment (vessels, columns, reactors, pumps, compressors, heat exchangers, boilers, furnaces, storage tanks, etc.), and their auxiliary
  - systems;
  - instrumentation items (control and safety/relief valves, gauges, thermocouples, etc);
  - piping and pipe fittings;
  - safety health and environmental system hardware (intrusion alarms, site access controls, weigh bridges, fire alarms, building automation systems, HVAC, smoke detectors, sniffers, etc).

- The specification of an activity carried out by a system within a process plant;
  A specification of an activity includes:
  - identification;
  - decomposition structures;
  - connectivity, where information or material flows from one activity to another;
  - classification;
  - properties; and

- the involvement of systems, plant items and components, batches and streams of material, people and organisations in an activity.

Activities within scope include:
- transformation;
- transportation;
- change of property or state;
- holding.

- Schematic diagram;
  A symbol on a diagram can be linked to a physical object or activity.
  Diagrams within scope include:
  - process flow diagrams;
  - piping and instrumentation diagrams;
  - logic diatrams; and
  - instrument loop diagrams.

- Reference data library;
  A reference data library of classes can be used to specify the nature of:
  - an individual physical object;
  - an indvidual activity;
  - an individual document, organisation or person;
  - a composition or connection relationship between physical objects or activities;
  - the involvement of a physical object, document, organisation or person in an activity.

- Reference to a library of standard parts;
  A reference to a library of standard part can be made using ISO 13584.
  (NOTE: ISO 13584 is a format for a reference data library of classes of individual physical objects. Some information about a class of individual physical objects is within the scope of both ISO 13584 and this part of ISO 10303.)

- Person and organisation;
  Information about a person or organisation includes:
  - identification;
  - decomposition structures (for an organisation);
  - employment relationships;
  - classification; and
  - the involvment of a person or organisation in an activity.

- Documents.
  Information about a document includes:
  - identification;
  - decomposition structures;
  - classification;
  - the things that a document is about; and
  - the creation, or use, of a document by an activity.

The following are **outside** the scope of this part of ISO 10303:

- conceptual process design, using process simulators;
- simulation or functional testing of systems;
- 3D shape representation of the plant items, and their spatial configuration in a 3D model; (NOTE: This is in the scope of ISO 10303-227.)
- detailed building automation installation information; (NOTE: This is in the scope of ISO 10303-212 and ISO 10303-225.)
- detailed physical design of process controls and monitoring systems and of electrotechnical systems; (NOTE: This is in the scope of ISO 10303-212. However, the conceptual functional and physical design of process controls and monitoring systems and of electrotechnical systems is in the scope of this part of ISO 10303.)
- information about the plant infrastructure (buildings, steel structures, concrete structures, roads, platforms, ladders, etc);
- management and cost information related to procurement and construction;
- information about actual, real-time, stream measurements (e.g. flow, pressure, temperature, composition) and equipment monitoring (e.g. vibration monitoring);
- information related to plant operations and maintenance.

(NOTE: The schema for this part of ISO 10303 is specified by reference to application module ISO 10303-1xxx, 'Functional data and their schematic representation'. ISO 10303-1xxx references further application modules.)

(NOTE: There is a substantial overlap in scope between this part of ISO 10303 and ISO 10303-227. The overlap in scope is summarised at http://www.uspi.nl/ISO_10303_221/wg3nxxx.html)

Five conformance classes are defined, as follows:

cc1: Plant system functional design with core classes

This conformance class **supports**:

- the identification of plant items (systems, equipment and their components);
- the composition and connectivity of plant items;
- the classification of plant items with respect to a core set of standard classes;
- properties of plant items.

This conformance class **does not support**:

- change history for a plant design;
- change history for an actual plant;
- design or process activities;
- user defined reference data libraries;
- documents and document structure;
- involvement of people and organisations in activities;
- schematic representation.

(NOTE: This conformance class supports the exchange of information between implementations of this part of ISO 10303 and implementations of ISO 10303-227.)

cc2: Plant system functional design with core classes and schematic representation

This conformance class supports:

- all of conformance class 1; and
- schematic representation.

(NOTE: This conformance class supports exchange between intelligent P&ID applications.

cc3: Reference data library

This conformance class **supports**:

- classes of product, activity, document, and person;
- classes of composition and connection relationship;
- set theory relationships between classes;
- external references to parts libraries according to ISO 13584.

This conformance class **does not support**:

- plant designs or actual plants;
- schematic representation.

(NOTE: This conformance class supports the exchange of reference data libraries. These reference data libraries may be used subsequently to classify items within a process plant design or actual process plant.)

cc4: Functional data

This conformance class **supports**:

- the identification of plant items (systems, equipment and their components);
- the composition and connectivity of plant items;
- the classification of plant items with respect to a core set of standard classes;
- properties of plant items;
- design or process activities;
- user defined reference data libraries;
- documents and document structure;
- involvement of people and organisations in activities;

This conformance class **does not support**:

- schematic representation.

(NOTE: This conformance class encompasses conformance classes 1 and 3.)

cc5: Functional data and schematic representation

This conformance class supports:

- all of conformance class 4; and
- schematic representation.

(NOTES: This conformance class corresponds to the complete scope of this part of ISO 10303. This conformance class supports exchange between process plant data warehouses.)

Each conformance class in this part of ISO 10303 corresponds to an application module as follow:

Conformance Class	Application Module
1	ISO/TS 10303-1xxx, Plant system functional data
2	ISO/TS 10303-1xxx, Plant system functional data and schematic representation
3	ISO/TS 10303-1xxx, Reference data library
4	ISO/TS 10303-1xxx, Functional data
5	ISO/TS 10303-1xxx, Functional data and schematic representation

Each of the application modules for conformance classes 1, 2, 3 and 4 is a subset of the application module for conformance class 5. It is expected that the modules will be submitted for CD/TS ballot during the 1st Quarter of 2002.

2.7.9 AP223: Exchange of design and manufacturing product information for cast parts (ISO/PWI 10303-223)

(AP223 has been inactive. It is anticipated that it will be reinitiated in 2003.)

"This part of ISO 10303 specifies the exchange, archiving and sharing of design and manufacturing product information for cast parts. …

The following are **within** the scope of this part of ISO 10303:

- Parts and process plans for parts that are made by sand, die, and investment casting processes;
- Design data for cast parts, including geometry, materials, tolerances, required physical and mechanical properties, required tests;
- Characterization of products used to make cast parts, including molds, dies, equipment, materials, and consumable items;
- Specifications for patterns and die assemblies;
- Input to and output from casting process simulation software;
- Data exchange between customer and foundry, within the foundry, and between foundry and supplier;
- Use of data for foundry automation and shop floor control;
- Use of data for archiving of design and manufacturing data for cast parts.

The following are **outside** the scope of this part of ISO 10303:

- Data describing rules, guidelines and expert knowledge used to design and manufacture cast parts;

- Data describing why a particular design or manufacturing decision was made;
- Shop floor scheduling data;
- Process plans for making patterns, dies, and other tooling;
- Algorithms used to obtain simulation results."

2.7.10 AP226: Ship mechanical systems (ISO/CD 10303-226)

(ISO/CD 10303-226's four (4) month Committee Draft (CD) ballot started on 12 December 2001 and will end on 12 April 2002.) (http://www.nist.gov/sc4/step/parts/part226/cd)

The following are **within** the scope of this Part of ISO 10303:

- The representation of the mechanical systems and their principal components for both naval and commercial ships;
- The product definition data pertaining to the following lifecycle phases of the ship mechanical systems:
  - Specification;
  - Design/Selection; (**NOTE** - The design data will be supported for those components that are designed and manufactured within the context of marine industry as shown in the AAM (Annex F). **For example,** data necessary to design a diesel engine will not be supported while data required to design a marine propulsor will be supported.)
  - Approval;
  - Installation;
  - Commissioning/Acceptance;
  - Operation;
  - In-Service Inspection and Maintenance;
  - Decommissioning/Disposal.
- The product definitions of the following mechanical systems:
  - the components in the systems that supply air to the engine room such as engine room ventilation fans and exhaust gas system such as silencers, economiser and so on.
  - the components in the fuel oil treatment and supply systems, engine lubricating system and engine cooling system.
  - the propulsion system: including main engines, shafts, couplings, gearing and propulsor;
  - the maneuvering system, consisting of the rudder, stock and actuator; thrusters including azimuthing thrusters; hydroplanes stock and actuator; stabilisers; cycloidal propellers type units; pivoting nozzles and water jet type systems.
  - the power systems including electric propulsion and auxiliary electrical generation;
- The product definitions of the following mechanical components:
  - the main engine;
  - pumps necessary for the operation of the main propulsion and essential machinery such as boiler feed, condensation extraction, fuel oil pumps, lubricating oil pumps and cooling water pumps.
  - the auxiliary machinery such as heat exchangers, air compressors and air receivers;
  - boilers;
  - auxiliary engines and thruster units;

- deck machinery such as windlasses, winches, capstans, cranes and derricks;
- The distinction between the physical specifications and the functional specifications of various systems and components.

- The following product definition information:
  - the functional and physical connectivity between components and between systems including physical connectivity of equipment to ship structure;
  - functional description of components and systems such as performance and operational characteristics;
  - geometric representation of systems and components to a level compatible to lifecycle phases of the corresponding system and component;
  - technological information such as material, tolerance, noise, vibration, shock and stress characteristics;
  - data that are necessary for tracking a component's lifecycle and operational history such as specification, in-service inspection and maintenance data.

The following are **outside** the scope of this Part of 10303:

The product definition data and physical connectivity pertaining to the following components and systems including:

- the piping arrangements not integral to the machinery unit;
- the electrical distribution systems not integral to the machinery unit;
- the control systems not integral to the machinery unit;
- maintenance equipment such as cranes, tools and so on.
- the ship's arrangement and compartmentation;
- the ship's Heating, Ventilation and Air Conditioning (HVAC) systems;
- the mission specific mechanical systems of the ship including:
- cargo refrigeration
- naval military equipment
- the outfitting of the ship, including hatch covers, watertight doors, fire fighting appliances, anchor and chain cables, davits and lifesaving appliances,
- sewage systems;
- data relating to the manufacture of the components.

This part of ISO 10303 specifies three (3) conformance classes that may be supported by an implementation. The conformance classes are:

Class 1: The representation of the mechanical systems and their principal equipment.
Class 2: The product structure and connectivity information of the mechanical systems and their principal equipment.
Class 3: The parametric data for mechanical systems and their principal equipment. The data would relate to one or more aspects of a mechanical product's lifecycle including the product's specification, general characteristics, functional and physical design, operational characteristics, engineering analysis, related tasks, related materials and related anomalies. The definitions of data elements are included in ISO 1354 compliant dictionaries for this part of ISO 10303.

Conformance to a particular class requires that all of the AIM elements defined in Clause 6 as part of that class be supported.

2.7.11 AP229: Design and manufacturing product information for forged parts (ISO/PWI 10303-229)

(AP229 has been inactive. It is anticipated that it will be re-initiated in 2003 or 2004.)

This AP will address the exchange, archival storage and sharing of design and manufacturing product information for forged parts. The forging process involves transforming the primary stock into a finished part with possibly a number of intermediate stages. Distinct products which make up stages in this sequence, and which are defined in this AP, **include**: primary stock, preform, near-net shape part after forging and net shape or finished part after finishing operation. Included are the characteristics of any of the above listed parts such as geometry, tolerances, surface finish, functional requirements, e.g., maximum design stress, material, and inspection and testing results. The characteristics of the forging process are also included, such as forging method, forging steps and lubrication. Also included within the scope of this AP is the tooling and equipment specification.

The following are **outside** the scope of this AP:

- process selection for near net shape manufacturing,
- product design modification for forging,
- management decisions used to forge a part,
- processing of the primary stock,
- forging die making,
- process control method,
- forging process simulation methods,
- finishing techniques and equipment,
- inspection techniques and equipment.

2.7.12 AP230: Building structural frame: steelwork (ISO/WD 10303-230)

(AP 230 is currently “on hold” --- See comments in 2.8.3)

This Application Protocol (AP) is a principal member of the suite of related Reference Models, Resources and AP’s within the Building and Construction Application Domain. The AP is concerned with the steel frames of buildings and similar structures. It will focus initially on the design phase of the life-cycle, but will be progressively extended into manufacturing and erection. A key feature will be the close integration of the information concerned with structural analysis, member and connection design, and detailing for fabrication and erection. Initially, a single Building Construction AP for structural steelwork is proposed. However it is expected that this AP (and other APs in the structural engineering family) will be partitioned into "Design" and "Construction".
AP230 will draw from ongoing work within the Eureka CIMsteel project. This project involves some 42 collaborators in eight countries (Austria, Denmark, Finland, France, Italy, The

Netherlands, Sweden and the United Kingdom), plus a growing number of associate collaborators.
The introduction of other new work items to create sister Building Structural Frame APs is anticipated. One for reinforced concrete is likely to be the most immediate. Collectively such APs will form the Building Construction "structural engineering family" and will share common resource models. The latter will evolve organically with inputs from each new work item and are expected to grow into a family core model. Many of the family APs will be applicable in other AEC sectors. For example, the current steelwork AP is applicable within the Process Plant sector.
The AP will be applicable to commercial buildings, industrial buildings, recreational buildings and other similar steel framed structures. It will address the (steel) frame of such structures - the systems with the function of transmitting the applied loads on the components of the building, including their dead load, to the ground.
The scope of the AP **will include**:

- design loads
- topology of the structural system
- structural analysis
- design of the structural members
- detailing the members including their connections
- fabrication of the members
- delivery to site
- erection of the frame
- quality assurance

Simple pad foundations will also be included in the AP.

However, it is the intention that aspects such as foundations and sub-structures, composite (steel/concrete) members, and structural frames which include separate steel concrete sub-systems will be addressed progressively by compatibility across the emerging family of structural engineering AP's.

The AP is primarily aimed at the requirements of the structural engineer in the design office, in the factory and on site. However, the AP will also be of value to architects, services engineers, quantity surveyors and other specialists. Implicit 3D geometry will, for example, allow other schematic views to be developed.

The following scope statement comes from the Working Draft (WD) of AP230. (See http://www.leeds.ac.uk/civil/research/cae/step/ap230/ap_doc/ap_c1/ap_c1.htm)

"This part of ISO 10303 specifies the use of integrated resources to satisfy requirements for the exchange of computer-interpretable information relating to structural
steel building frames - which are considered purely from the standpoint of a structural engineer.

The life-cycle of a building can be decomposed into five separate stages: (i) plan, (ii) design, (iii) construct, (iv) use (including operate and maintain), and (v) demolish. AP230 supports the exchange of data during the first three stages of this list.

The first three stages of a building life cycle - plan, design, and construct - are completed as the result of planning, design, construction and (ongoing) management activities.

The planning and management of building quality results in the generation of project technical specifications and applicable standards - both of which govern design. In turn, project planners and managers make use of feedback from design and construction activities. In the case of steel-framed buildings, design activities generate steelwork schedules, detailed designs, general arrangements and various types of feedback to project managers and planners. Input from designers informs and directs the fabricators and erectors of steel-framed building superstructures. Of these information flow and activities, AP230 addresses: the transfer of quality-specifications information into design, design activities, the feedback of information from designers to project planners / managers, the transfer of information into fabrication and erections, and the feedback of information from fabricators and erectors to project planners / managers.

Under design activities, AP230 addresses: structural design, loading assessment, structural scheme modelling, structural analysis, member design, connection design, and steelwork detailing.

The products addressed by AP230 - steelwork building frames and their components - are employed in low, medium and high rise construction in domestic, commercial and industrial applications. The AP is applicable to a variety of structures ranging from simple, single-story portal frame industrial "sheds" to multi-story office blocks. The main structural steelwork is covered, as is secondary steelwork - such as purlins, siderails, cleats and cladding. The frames considered may be braced or unbraced. Connections can be pinned, rigid, or semi-rigid - rigid and semi-rigid being full or partial strength. The data model underlying this AP views frames as being fabricated from manufacturing assemblies, and, in turn, views manufacturing assemblies as being made up of parts and joint systems. Parts can be prismatic, prismatic-derived or two dimensional.

EXAMPLES:

- A prismatic part is, typically, a rolled section.
- Prismatic-derived parts include castelated and tapered beams.
- Two dimensional parts include plates and sheets.

The AP includes support for rolled, welded, cast, or cold-formed parts (although only limited information is held on cast and cold-formed parts).

Welded and bolted joint systems are covered, and bolted joint systems may involve ordinary and pre-loaded bolts.

In general terms, the data supported by AP230 include: geometrical and geographical data, data relating to physical and material characteristics, data relating to structural behaviour, data relating to unique identification, logical grouping data, and temporal data. These data types can also be described - more specifically – in terms of the sorts of entity to which they relate.

This part of ISO10303 **specifies** the following:

- persons and organizations (names and addresses)
- projects (descriptions)
- sites (descriptions and locations)
- analytical models (connectivity and properties of elements and nodes) (**EXAMPLE**: Element properties considered by AP230 include elastic and plastic behaviours, temperature related material strengths, thickness related material strengths, and multi-linear elasticities.)
- loads (values of basic cases and combinations) (**EXAMPLE**: Loads considered by AP230 include dead loads, imposed loads, wind loads, snow loads, and equivalent static loads (for seismic / dynamic analysis). Element loads may be applied to global or local axes, and may be destabilising.)
- analysis results (sets of values of forces at nodes and within elements)
- structures (locations, connectivity, and characteristics of parts, joints and sub-structures) (**EXAMPLES:** (1) Part-modifications covered by AP230 include notches and chamfers, skews, hole groups. and (2) Part-descriptions supported by AP230 include references to standard and manufacturers' items, and representation in terms of implicit geometry.)
- design assemblies (connectivity and descriptions of members, connections, and frames)

The following are **outside** the scope of this part of ISO 10303:

- complex parts,
- complex features,
- complex joint systems,
- curved prismatic parts,
- non-isotropic materials,
- non-standard fabricated beams, (**EXAMPLE**: A typical fabricated beam is a plate girder.)
- crane rails,
- compound beams,
- second order elastic analysis,
- holding down bolts,
- studs (used in joint systems),
- threaded rods,
- pins,
- cambered beams,
- dimensional tolerances,
- bearing surfaces,
- elastic bearings,
- movement joints,
- dynamic / cyclic loading, (**EXAMPLE**: Typical sources of dynamic loads are earthquakes, explosions, and vibration.)
- moving loads (**EXAMPLE**: A typical moving load is a highway load.)
- 3D solid modelling and detailed FEA,

- cost issues,
- organizational issues (within and between companies),
- contractual arrangements, and
- composite construction."

(**NOTE**: AP230 may be applicable to related structures such as bridges, transmission towers, and offshore structures, but is not specifically aimed at such structures.)

Conformance Classes:
http://www.leeds.ac.uk/civil/research/cae/step/ap230/ap_doc/ap_c6/ap_c6.htm

"Conformance class 1: analysis
This class includes information required by, and produced by, activities that are associated with structural analysis. This class is concerned with analytical models (comprising nodes, elements, boundary conditions, element geometry, material and end releases), loadings, load combinations, and analysis results.

Conformance class 2: member design
This class includes information produced by the activities that are associated with the design of structural members. Thus, it is concerned with design assemblies which may be structural frames or structural members. These design assemblies ultimately decompose into design parts and connectors. The design parts are specified by specific parts, which are more precisely defined in terms of material properties and geometry than were the equivalent analytical elements. The goal of activities covered by this conformance class is to determine whether structural members and frames are fit for purpose - in terms of serviceablity and ultimate strength. This class is concerned with the concept that structural members are connected, and ultimately, that one part is connected to another. It is not concerned with how those connections are made.

Conformance class 3: connection design

This class includes information produced by the activities that are associated with the design of structural connections. Thus, it is concerned with design assemblies of the type structural connection, and their relationships with the associated structural members. These design assemblies ultimately decompose into design parts and connectors. The design parts are specified by specific parts. They are defined in terms of material properties and geometry. The connectors are specified by specific joint systems, which are either bolt systems or weld systems. It is concerned with whether Structural Connections are fit for their purpose, in terms of serviceablity and ultimate strength. This class is concerned with how connections between structural members are made, and how each part is connected to another to form those connections. It isconcerned with the specification of bolted and welded connections; i.e. how welds, bolts, nuts, washers and parts are geometrically arranged

Conformance class 4: detailing
This class includes information produced by the activities that are associated with the detailing of structural steelwork. Thus, it is concerned with manufacturing assemblies, and their relationship with the associated parts and joints. The located parts are specified by specific parts. They are

defined in terms of material properties and geometry. The located joint systems are specified by specific joint systems, which are either bolt systems or weld systems. The located parts may be modified by a number of located features - specified by specific features. This class is concerned with the dimensions of the physical components of a steelwork structure and with how those concepts are physically realized; i.e. how each part is connected to another, and how welds, bolts, nuts, washers and parts are geometrically arranged to form the complete structure."

2.7.13 AP231: Process design and process specifications of major equipment (ISO/CD 10303-231)

(AP 231 is currently inactive --- See 2.8.3)

This application protocol (AP) addresses the exchange of process engineering and conceptual design information for process industry facilities. Process industries include, but are not limited to, chemical, gas processing, petroleum, and the engineering and construction industries. This does not preclude support for the requirements of the food and beverage, ore processing, pharmaceutical, power generation, pulp and paper, and water and waste processing industries.

Process engineering information is used throughout the process plant life cycle. Process engineering information is initially generated during the process system design activities, including conceptual and final process design and a portion of the detailed engineering design specifications of process equipment. Process engineering information can be used to produce process flow diagrams (PFDs), equipment and instrument lists, process specifications on equipment datasheets, and to populate databases with process information needed later in the life cycle, e.g., process stream data. This information forms the conceptual basis for the specification, selection, and operation of process plant equipment over the plant life cycle. This AP supports continuous and batch processes, process simulations, stream data, unit operations, conceptual design requirements for major process equipment, and conceptual process control strategies. The primary life cycle perspective is that of conceptual process engineering done prior to the detailed design and construction of new process plants or the modification of existing plants.

This application protocol defines the context, scope and information requirements for the exchange of process engineering data as detailed in the exchange scenarios described below and specifies the integrated resources necessary to satisfy these requirements. The AP purposes are:

- Exchange of the process engineering portion of initial and revised process design packages between operating company and an engineering company;
- Exchange of process engineering information within an organization among various software packages that support the process engineering work activity, including internally owned software and software licensed from different software providers;
- Exchange of process engineering information among various software packages involved in various stages of the plant life cycle, which may involve disciplines other than process engineering, and which need to use process engineering information;

- Transmission of the process engineering portion of a technology package from a licensing company to an engineering company or an operating company;
- Transmission of the process engineering portion of a process design package within a company, such as from a central office to an operating plant for review and comment;
- Transmission of the process engineering portion of a facility description during the sale of the facility.

2.7.14 AP233: Systems engineering data representation (ISO/WD 10303-233, ISO/WD PAS 20542)

(AP233 is also registered as Publicly Available Specification (PAS) 20542 within ISO TC184/SC4. A Working Draft of AP233/PAS 20542 can be found at the following web site: http://www.sedres.com/documents/pas/Index.htm) (See also 2.8.5)

The aim of this AP/PAS is to define a standard that would address the System Engineering (SE) data exchange issues. System Engineering embraces several aspects:

- technical aspects which lead to the definition of functional and physical architectures,
- technical management (work schedule, document generation, concurrent engineering, validation and verification procedures...),
- project aspects which take into account project management issues (traceability management, configuration management, trade-off analysis...),
- industrial management (partners co-operation management...).

In this context, the term "System" comprises:

- Avionics systems (mission, communication, navigation, human/system interface,...) and
- Airframe systems (crew/passenger escape, power generation and distribution, environment control, fuel management...).

In a launcher design it would cover electrical aspects of the launcher as well as its mechanical definition.

"In an industrial context, the development of a system has to go through a set of 6 separate phases (that) are summed-up below.

- **Phase 1:** Feasibility assessment phase. This very first phase usually ends with a contract between the customer and the industrial partner. It helps the dialogue between customer and industry. This first phase also leads to the definition of the financial envelope, and leads to industrial scheme if required.
- **Phase 2:** System design. This phase covers all the aspects of the system that should be designed. For instance, for a satellite, it covers the design of the satellite it-self, but also the design of ground stations and their interfaces with each other, the links with the launcher, etc. Each part of the overall system is then described by a specification document (the word document should be interpreted broadly. It covers paper documents as well as electronic documents). Each part may in turn be decomposed as a set of more simple parts. Each sub system can be built by separated but co-ordinated teams. For instance, a team may be in charge of the realisation of the electric parts of the vehicle,

whereas an other team may be in charge of the mechanical aspects. Since both sub-systems come from a common root, they will be compatible.

- **Phase 3:** Realisation. This phase covers the effective production of each part according to the specifications (that) come from the previous phase. This phase is covered by STEP.
- **Phase 4:** Use. This phase covers the time when the system is in real use.
- **Phase 5:** Maintenance. This phase may necessitate special functionalities such as special tests, or special features (doors in an airframe...).
- **Phase 6:** Dismantle. This phase deals with the operations (that) have to be performed when a system comes to the end of its life. For instance, for a missile, this phase is mandatory. This phase is more and more important in product design since they have to be recycled."

The present AP/PAS focuses on **Phase 2: System design**. Some other phases are already addressed by STEP (for instance **Phase 3** is already covered by STEP).

"This document establishes the requirements for the exchange of information between stake holders in the systems engineering process."

The following is the Scope as taken from the Working Draft of PAS 20542.

"This part of ISO 10303 specifies the exchange and sharing of design and configuration control product information pertaining to the design and validation phases for a system from the viewpoint of a systems engineer. …

This part of ISO 10303 supports the exchange of data during systems engineering and embraces several aspects:

- technical aspects which lead to the definition of functional and physical architectures (what the system is doing, how it is doing it and how well);
- technical management (work schedule, document generation, concurrent engineering, validation, and verification procedures);
- project aspects which include project management issues (traceability management, configuration management, and trade-off analysis);
- industrial management (management of co-operation between partners).

The following discipline views are **within** the scope of this part of ISO 10303:

- the definition of other the systems the system interacts with;
- the context for the system in each lifecycle phase; …
- the support of hierarchical break down and object oriented modelling techniques;
- the functional and non-functional requirements of the system in each lifecycle phase;
- the definition of the static and dynamic behaviour of the system.

The following life cycle stage is **within** the scope of this part of ISO 10303:

- systems engineering.

The following types of data are **within** the scope of this part of ISO 10303:

- data to describe the system;
- data to specify requirements of the system; …

- data to specify the static behaviour of the system in terms of functions and flows between functions; …
- data to specify dynamic behaviour of the system; …
- data to support the physical architecture;
- data to support the partitioning of the system;
- data to support the verification and validation of the system; …
- data to support project and industrial management; …
- data to support configuration management. …

The following discipline views are **outside** the scope of this part of ISO 10303:

- specialist disciplines.

The following life cycle stages are **outside** the scope of this part of ISO 10303:

- support the feasibility assessment of the system;
- domain engineering;
- support the realisation, operation, maintenance and decommissioning of the system.

The following types of data are **outside** the scope of this part of ISO 10303:

- data used solely in the domain engineering;
- data used solely in the life cycle stages feasibility assessment, realisation, operation, maintenance and decommissioning of the system."

2.7.15 AP234: Ship operational logs, records, and messages (ISO/AWI 10303-234)

(AP234 is currently inactive.)

OVERVIEW -
This part of ISO 10303 specifies an application protocol (AP) for the exchange and archiving of data that are generated during the operation of commercial ships. The data may be collected in logs, messages, and records, and may be archived on board or exchanged between ship and shore via satellite communication.

Information that is collected during ship operation is related to the ship product model as it has been populated during the new building phase of the ship life-cycle.

The integration of this AP234 with the existing shipbuilding related Application Protocols (AP215, AP216, AP217, AP218, AP226) is included in this work item. The work item will contribute to an extension of the current ship product model into ship operation to enable the creation and maintenance of a consistent ship data model throughout the life-cycle of a ship.

Ship operations companies use computer applications for the management of their ships. These applications are located both on shore and on the ship and may collect data from other IT applications onboard, that is the network of sensors that is used for data collection. The harmonisation of terminology between the control and monitoring network and the management application is in scope of this standard. This task involves a close collaboration with IEC

TC80/WG6 where the relevant network specification Maritime Information Technology Standard (MiTS) is being standardised.

This Application Protocol supports surface ships commercial use.

The following are **within** the scope of this part of ISO 10303:

- harmonisation with IEC 1162-4 standard real-time tags and data models relatedto real-time data from the monitoring system covering:
  a) navigation;
  b) equipment and machinery status;
  c) environmental observations;
  d) tank loading conditions;
  e) hull stress real time measurements.

  (**NOTE**: Some of the above real-time data are within the scope of existing ship application protocols. This applies e.g. to equipment and machinery data (AP226) and these information items will not be duplicated in AP234. The main objective of this part is to establish a general model for exchange of real-time data between applications like the control and monitoring system to non-real time data applications like the administrative systems onboard.)
- information quality for automatically and manually produced data
- - ship events and ship activities definitions for triggering collection of operational data from the monitoring system into standardised reports or non-standardised user defined reports.
- fuel oil quality report from laboratory to the operating ship;
- requisition messages for requisition, purchase and transport of spare parts to the ship;
- classification society survey (statutory) during the ship operation phase;
- ship safety record including:
  - vessel particulars;
  - vessel status;
  - crew requirements , the identification of crew positions, the corresponding license and training requirements, medical certificates, and required drills;
  - crew status, the identification of crew members, their certificates, training and medical records, and working hours;
  - voyage specific data, the voyage specific data including ports, cargo carried, loading pattern, ballast condition, and critical events;
  - record of inspection, the record of incidents including port state restrictions, unscheduled downtime, near misses, and pollution incidents;
  - record of incidents;
  - corrective actions needed for the ship including procedures, equipment, documentation, and a deficiency log;
  - reports including automatic identification system view, ship damage to coastal state.

    (**NOTE**: At this stage it is not intended that the ship safety record or any other part of this standard shall define mandatory reporting to port authorities or other authorities.)

2.7.16 AP235: Materials information for the design and verification of products (ISO/WD 10303-235)

"The engineering activities performed during the design and validation of a material object require materials information which goes beyond the specification of a particular stock material, or a required grade, such as found in a Bill of Materials.
The potential scope of the Material Information (MATINF) AP is very large, so it is proposed to limit the scope by defining a small set of application areas in which dictionaries of classes, material families and specifications will be standardised.

Hence the scope definition has two parts:

- Types of materials information which can be supported by the generic information model;
- Application areas for which standard dictionaries will be defined.

Types of materials information:
The MATINF AP will support the sharing and exchange of information that supports:

a) Properties of material volumes and material surfaces (i.e. properties that depend upon surface finish);
b) Different views of material information for different activities.

Each of these items will be addressed

- Classes of behaviour - The classes of behaviour **<u>within</u>** scope of the MATINF AP are:
  - ➢ structural: This class includes elastic and plastic deformation, creep, fracture, and fatigue. (NOTE: The term 'structural' is used with the same meaning as in ISO 10303-209:2001).
  - ➢ electrical: This class includes electric conduction and susceptibility to electric and magnetic fields.
  - ➢ thermal: This class includes heat transfer within volumes and across surfaces and thermal emissivity of surfaces.
  - ➢ optical: This class includes light refraction and dispersion.
  - ➢ chemical: This class includes contamination, moisture release, out-gassing and degradation of material objects.

The information about these classes of material object behaviour **<u>will include</u>**:

- ♦ material property variations with respect to the environmental conditions such as temperature and humidity; (NOTE: Material property variations with respect to environmental conditions provide links between the different classes of behaviour. For example, optical properties can depend upon strain, and electrical properties can depend upon temperature.
- ♦ creep, fracture, fatigue, corrosion and crazing of material volumes and material surfaces;
- ♦ material property distributions within a material object that include both orientation and composition variations;
- ♦ material property descriptions appropriate for different types of analysis;
- ♦ quality indicators for property values indicating their suitability for different analyses;
- ♦ the structure of composite materials, including fibre reinforced laminates and sandwich construction;

- ♦ the process of fabrication and conditioning for a material object, whether a product or a test specimen;
- ♦ allowables and design values for loads, for stresses, and for geometric edge margins associated with mechanical fasteners; (NOTE: Allowable here means that it is a strength value derived from the statistical reduction of data from a stable process.

Many properties are nominal (or fictional) and are derived from real properties by a process either specified by a standard or chosen according to a design philosophy. The MATINF AP will support information about the variation of material properties within families of material objects. The MATINF AP will support information (including version information) about national and international standards that are used to derive nominal properties of a manufactured material object, and to assess the safety of a manufactured material object.

- **Views of materials information**

Different subsets of materials information are required to support different engineering activities. The MATINF AP will support analytical model information about the properties and behaviour of a material object necessary for engineering analysis. Engineering analysis is used in various stages during the life of a material object, as follows:

- ➢ conceptual design: Coarse analytical models can be used for feasibility studies at an early stage in the design and analysis process. Such models need not have a realistic shape. For lumped parameter models, there is no shape information at all.
- ➢ detailed design: A more realistic analytical model is typically used to predict whether a material object intended for manufacture will meet performance requirements. Such a model may have a shape that is an idealisation of the CAD shape.assessment: A detailed analytical model of a material object is used in conjunction with design allowable stresses, strains, displacements, loads and/or edge margins to justify final approval of the material object for service.

Analytical model information can be derived from test data, and can be created as a result of a data reduction process that uses information obtained from many different tests.

- ➢ The MATINF AP will support the model information for <u>linear</u> behaviour defined within ISO DIS 10303-104 and ISO DIS 10303-209.
- ➢ Model information for <u>nonlinear</u> behaviour defined by ISO, CEN TC249 and groups such as VAMAS (Versailles Project on Advanced Materials And Standards) will also be supported.
- ➢ The MATINF AP will **<u>not</u>** support materials information relevant to business activities, such as cost analysis.

- Application areas for libraries Libraries will be standardised within the MATINF AP to support the following application areas.
  - ➢ Fibre-reinforced composites: The information exchange for the analysis and design of material objects of this class is already supported by ISO DIS 10303-209, Application protocol: Composite and metallic structural analysis and related design. The MATINF AP will support the sharing and exchange of information about the source of the material properties used in ISO 10303-209:2001. The library for fibre-reinforced composite materials within the MATINF AP will be based upon:

– the terms within the US Military Handbook 17 (MIL-HDBK-17);
– the test methods and meta-data for composite parts computerised by the ASTME49 committee.

- Structural metallic alloys: The library within the MATINF AP will be based upon the terms within the US Military Handbook 5 (MIL-HDBK-5). NOTE – The allowable values within MIL-HDBK-5 will not be included within the MATINF AP. However the classes of property and classes of material object within MIL-HDBK-5 will be included within the MATINF AP. This means that if the allowable values within MIL-HDBK-5 are stored in a data base, then the information can be exchanged or shared using the MATINF AP. The MATINF AP can also be used to exchange or share different values for the same properties.

Several European organisations have developed MSC/MVISION schemas for high temperature metallic materials test data, partly using ECCC volumes 2 and 4 to define data models. These organisations, and other users outside of ECCC from Europe and the US are at an early stage of preparing a common MVISION schema for high temperature metallic materials test data. A full EXPRESS schema will be produced (not necessarily consistent with existing parts of ISO 10303).

Part 1 of the Standard applies predominantly to un-reinforced and reinforced thermoplastic and thermosetting materials that may be either injection or compression moulded or prepared as sheets of specified thickness. This includes thermoplastics reinforced with short fibres (considered as reinforcing fillers).

Part 2 deals specifically with long or continuous fibre reinforced plastics. The test methods and test conditions described in this part apply to all fibre reinforced plastics composites regardless of the matrix type (thermoplastic or thermoset), the type of fibre reinforcement (glass, carbon, aramide) or the processing method used to produce the material.

The MATINF AP will have a separate conformance class for each application area. The MATINF AP will also have a conformance class for user defined libraries.

2.7.17 AP236: Furniture product data and project data (ISO/WD 10303-236)

The model described by this AP concerns the relationship among the manufactures, suppliers and the end-user (retailers, major retailers and private customers) in the scope of the furniture industry. This AP refers to product definition (furniture) and interior design projects (decorating projects) in order to allow the exchange of Product Libraries (catalogues and decorating projects) and Orders, including graphic information.

2.7.18 AP237: Computational fluid dynamics (ISO/AWI 10303-237)

(AP237 is an initial part of the Engineering Analysis Core Model (EACM))
(See 2.8.6 and http://www.nist.gov/sc4/nwi_pwi/nwi/step/fluid_dyn/doc for more detail.)

AP237 will define a standard for the sharing, exchange, and storage of fluid dynamics data. The information **within** scope will include digital flow field data, surface data, and integrated data

from three types of sources: (1) analysis and computation, (2) ground test (e.g., wind tunnel test), and (3) flight test. The first edition will focus on data related to analysis and computation. This work item consists of four parts:
- 10303-227, Application Protocol: Fluid Dynamics
- 10303-110, Integrated Application Resource: Computational Fluid Dynamics Data
- 10303-52, Integrated Resource: Mesh-Based Topology
- 10303-53, Integrated Resource: Numerical Analysis

Part 110: Integrated Application Resource: Computational fluid dynamics data

Part 52: Integrated Resource: Mesh-based topology
The following are **within** the scope of this part of ISO 10303:
— Mesh-based topologies;
— Multiblock mesh interfaces;
— Data arrays.
The following are **outside** the scope of this part of ISO 10303:
— Applications of mesh topologies;
— Applications of data arrays.

Part 53: Integrated Resource: Numerical analysis
The following are **within** the scope of this part of ISO 10303:
— application-independent numerical analysis;
— idealisations of action and product definitions evinced by numerical analyses.
The following are **outside** the scope of this part of ISO 10303:
— numerical analysis applications;

2.7.19 AP238: Application interpreted model for computerized numerical controllers (STEP-NC) (ISO/PWI 10303-238)

(AP238 has been formulated as a Preliminary Work Item (PWI), but has not yet been balloted as a New Work Item (NWI).)

This part of ISO 10303 specifies the application interpreted model (AIM) for the information requirements defined by the ISO 14649 Data model for computerized numerical controllers.
(NO Conformance Classes Specified Yet) (For more information, see 2.8.1, Appendix C and http://www.steptools.com/library/stepnc/tech_resources/)

2.7.20 AP239: Product life cycle support (PLCS) (ISO/AWI 10303-239)

“The Product Life Cycle Core AP will provide a framework for integrating, exchanging and managing the technical data required to maintain a complex, and changing product over its life cycle.
The Product Life Cycle Core is the first in a series of ISO Specifications planned by PLCS, Inc. which together will provide an integration and exchange capability for product life cycle support data.

The Core will provide a comprehensive configuration definition for the products needing support, down to the level of a serialised product instance. The Core can also be used to identify, integrate, navigate, approve and control the effectivity of a wide range of related information required to deliver product life cycle support.

The PLCS Core **will provide** the following capabilities:

a) the ability to define and control changes to the configuration of a product, and its related information, to the level of the individual product or support including the management of change after build and "configure for role" and the formation of multiple product breakdown views (e.g. functional, physical, zonal) and relationships between them;

b) a capabilty to identify and associate information to interfaces between product elements

c) an ability to hold, generate and manage the effectivity of the wide range of documents required by support personnel, including product descriptions, images, drawings, CAD Files, feedback reports, support analyses etc. A wide range of document formats will be supported;

d) a capability to define predicted, calculated and measured properties of relevence to support activities

e) a capability to define personnel, organisations and locations including their roles and authority in support processes

f) the ability to define sets and classes of Reference Data of relevance to support;

g) the ability to define and associate other data to predicted and actual (historic) events;

h) the ability to establish and use Reference Data Libraries from ISO 15926 and other sources.

Availability of this information, in an integrated form, will provide the means to define and monitor the delivery of a specified support performance at minimum life cycle cost."

(For more information, see 2.8.5)

The next section provides some descriptions of "suites" of STEP Application Protocols as they apply to general application domains. In contrast to the way in which AP214 (ISO 10303-214:2001) - "Core Data for Automotive Mechanical Design Processes" addresses the Automotive domain in a single Application Protocol, the following "suites" use a series of Application Protocols, Integrated Resources, and Application Integrated Resoures to address the application domain. Here, we briefly identify the Manufacturing Suite, the Shipbuilding Suite, the Process Plant Suite, the Electrical/Electronic Suite, the System Engineering Suite, and the Engineering Analysis Core Model and indicate some of the pilot/prototype/prove-out activities in these application domains. Some additional references are cited for further information.

2.8 STEP Application Suites

2.8.1 Manufacturing Suite

The following STEP AP's and related ISO Standards represent the potential for a very robust manufacturing suite. (See Documents 12, 14, 15, 16, and 17 in Appendix A and the web sites http://isg.scra.org/teams/step.html and http://www.steptools.com/library/stepnc/tech_resources)

Figure 6 (below) depicts a STEP-enabled Manufacturing Environment in which these AP's are integrated.

AP213 - Numerical Control Process Plans for Machined Parts – ISO/DIS 10303-213
(See 2.7.2 and Document 14 in Appendix A.)

AP213 is now out of date. It supports only geometry and not the more intelligent machining features as defined by AP224. It supports the reference to the old NC data and not the more intelligent work plan as defined by ISO 14649. Therefore, if AP213 is to be moved forward as a standard, it needs to be updated to harmonize with these existing standards. (This is planned as part of the TACOM N-STEP)

AP224 - Mechanical Product Definition for Process Planning Using Machining Features – ISO 10303-224:2001 (Edition 2) (See 2.6.9)

AP224 contains all of the information necessary to manufacture the required part

- All necessary CAD geometry and topology in a neutral format;
- Machining feature information such as: hole, boss, slot, groove, pocket, chamfer, fillet, etc.;
- Dimensional and geometric tolerance information;
- Part properties such as: material properties, process properties, material hardness, etc.;
- Administrative information such as: approval, part name and id, delivery date, quantity, etc;
- The capability to handle both discrete parts and assemblies of parts.

AP219 - Manage dimensional inspection of solid parts or assemblies
(ISO/PWI 10303-219) (See 2.7.6)

AP219 requirements include references to 'as designed geometry' and 'as designed tolerances' and also requires inspection data from process planning.

AP238 – Application interpreted model for computerized numerical control (STEP-NC)
(ISO/PWI 10303-238) (See 2.7.19 and Document 17 in Appendix A)

AP238 will specify the Application Interpreted Model (AIM) for the requirements defined by the ISO 14649 data model for computerized numerical controllers.

ISO 14649 - Data Model for Computerized Numerical Controllers (CNC)
(Being developed in TC184/SC1/WG7) (See Appendix C for more details on the Scopes of the ISO 14649 Parts and Documents 14, 15, 16, & 17 in Appendix A.)

For several decades data for NC machine controllers has been defined by using ISO 6983. This standard defined a series of "G" and "M" codes that define machine controller functions and motion. ISO 6983 only has the capability of specifying basic motion and switch commands. Instead of trying to modernize this standard, a new standard, ISO 14649, is being developed to handle the next generation NC machine controllers.

The scope for ISO 14649 **includes**:

- Re-establish an accepted standard for the transmission of NC data to the shop floor;
- Provide motion control data based on geometric splines for sophisticated, high-speed NC cutting operations;
- Avoid intermediate data formats (CLDATA);
- Provide all necessary data for easy modification of NC data at the machine controller;
- Task-oriented data structure;
- Enable feedback of modified NC data from the shop floor to higher-level departments;
- Minimize the need for data conversion by using standards for geometric representation.

ISO/DIS 14649-1 Overview and fundamental principles

ISO/DIS 14649-10 General process data
This part of ISO 14649 specifies the process data that is generally needed for NC-programming within all machining technologies. These data elements describe the interface between a computerized numerical controller and the programming system (i.e. CAM system or shop floor programming system). This part of ISO 14649 cannot stand alone. An implementation needs at least one technology-specific part (e.g. ISO 14649-11 for milling, ISO 14649-12 for turning). Additionally, the schema uses machining features similar to ISO 10303-224 and ISO 10303-214. The description of process data is done using the EXPRESS language as defined in ISO 10303-11. The encoding of the data is done using ISO 10303-21.

ISO/DIS 14649-11 - Process data for milling
The purpose of ISO 14649 - 11 is to:

♦ Re-establish an accepted standard for the transmission of NC data to the shop floor!
♦ Provide motion control data based on splines for sophisticated, high-speed NC cutting operations
♦ Avoid intermediate data formats (CLDATA)
♦ Provide all necessary data for easy modification of NC data at the machine controller
♦ Replaces the old “M and G” codes with “working steps”

This part of ISO14649 specifies the data elements needed as process data for milling

ISO/NWI 14649-12 Process data for turning (To be developed)

ISO/DIS 14649-111 Tools for milling

ISO/NWI 14649-112 Tools for turning (To be developed)

ISO/DIS 13399: Cutting tool data representation and exchange
(Being developed in ISO TC29/WG34)

ISO/DIS 13399-1: Overview and fundamental principles.
This International Standard defines an electronic representation of the data for cutting tools and the structure needed to connect these data together. This standard is intended to facilitate the use and manipulation of cutting tools data within and between manufacturing software systems.

ISO/DIS 13399-2: Reference hierarchy for cutting tools.

ISO/DIS 13399-3: General data for cutting tools.

ISO/DIS 13399-4: Turning tools data.

Harmonization is essential to the success of any group of standards. For example, AP224 defines machining features and their associated geometry. AP213 will use the same feature definitions to define the appropriate material-removal activity. AP219 will use the same feature definitions to inspect the manufactured part relative to the "as designed" part. Finally, ISO 14649/AP238 will use that same feature definition, and join it with the machining operation for use by intelligent machine controllers. This harmonization creates common, unambiguous data for use throughout the manufacturing process. ISO committees are working to fine-tune the harmonization of these standards.

The diagram below shows an integration/implementation scenario for the STEP Manufacturing Suite.

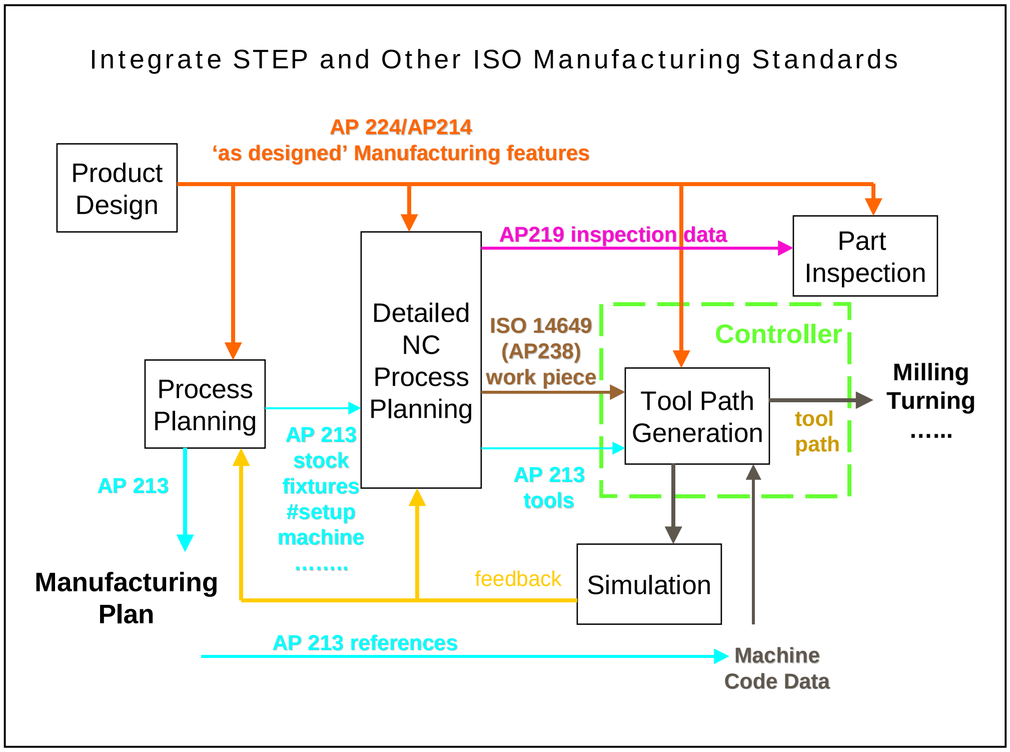

Figure 6: Integrated STEP Manufacturing Suite

Until now (except for RAMP & UKRAMP), the use of "STEP" for manufacturing has been accomplished primarily by CAM applications being "fed" by AP203 data supported by the "paper" engineering drawing (or electronic drawing files in formats such as DWG, DXF, IGES, …), which provide the additional information such as dimensions and tolerances, notes and specifications, material call-outs, etc., required by manufacturing for process planning and fabrication. The role of AP203 in this scenario is to provide the 3D solid model of the part for use in NC coding. STEP AP201 (Explicit Draughting) and AP202 (Associative Draughting) and conformance classes 3 & 4 of AP214 also contain this drawing information, but lack widespread vendor implementations at this time. There is, however, a degree of use of AP202 in Japan.

Other STEP Application Protocols that "fit" in the manufacturing domain are AP's 207, 223, and 229. AP207 (Sheet metal die planning and design – See 2.6.4) has already achieved IS status. AP223 (Exchange of design and manufacturing product information for cast parts – See 2.7.9) and AP229 (Design and manufacturing product information for forged parts – See 2.7.11) have been dormant for the past 3 – 5 years, but are expected to be resurrected in the next year or two.

AP232 (Technical data packaging core information and exchange – See 2.6.12) is an integral tool for supply chain integration in essentially all application domains. AP232 achieved IS status in 2001 and will be published in 2002. AP232, which includes the STEP PDM Schema as a proper subset, is being implemented in production in the aerospace and defense industries in the United States and Europe to deliver the "build to" technical data package. See Sections 5, 6 & 7 for Pilot Implementations (Section 5)(e.g., STIR, STEPwise, STAMP, VAST, …), Production Implementations (Section 6) (e.g., Boeing, Lockheed Martin, EADS, …), and some discussion (Section 7) on the important role of AP232 throughout the product lifecycle.

STEP R&D Projects That Address Manufacturing

There are several on-going Research and Development (R&D) projects throughout the world that are addressing STEP and Manufacturing.

- The Rapid Acquisition of Manufactured Parts (RAMP) Project has been in existence since 1986 addressing standards driven applications for the manufacture of mechanical and electrical parts and assemblies. STEP AP224 was developed and implemented as a part of the RAMP Program. Standards driven applications were developed in an R&D environment and put into production at DoD Depots and several commercial sites. This program was initially funded by the Naval Supply Systems Command (NAVSUP) and later by the Defense Logistics Agency (DLA). The TACOM NAC is the current sponsor of the Technology under DLA's Strategic Sourcing Technologies (SST) contract. Much of the work in the mechanical domain will be an integral part of the N-STEP Program under TACOM NAC (For more information, see Section 6 and visit http://www.isg.scra.org for a copy of The STEP Manufacturing Suite White Paper.)
- The UK RAMP Program is an implementation of the RAMP technology in the United Kingdom. This program has been in place since 1998 and is used in production. It is funded by the UK Ministry of Defence.
- The European Commission's STEP-NC Program is funded by ESPRIT. It is a highly visible Program with participants worldwide in Europe, the Far East and the United States. A primary objective of this program is the development and prove-out of the ISO 14649 standards as a replacement for ISO 6983:1982 and to eventually eliminate the use of the RS274D M- and G- codes for programming NC Controller. Participants include Industry, Universities and NC Tool Vendors. The Program started in January 1999 and will end in December 2001. (For more information, visit http://www.step-nc.org)
- STEP Tools, Inc's Super Model Project is the name given to the Model Driven Intelligent Control of Manufacturing Project and is funded under NIST's Advanced Technology Program (ATP). Its goal is to "utilize the STEP-NC and other standards in order to develop an open database of all the information necessary to design and manufacture apart. "Related to this project is STEP Tools, Inc's participation in the EC STEP-NC Project and their STEP-NC prototype demonstrations using STEP and ISO 14649 technology. (For more information visit http://www.steptools.com)
- The Intelligent Manufacturing Systems (IMS) Program is a worldwide consortium addressing many areas in the manufacturing domain. (For more information visit http://www.ims.org)
- The Rapid Response Manufacturing (RRM) Program was a National Center for Manufacturing Sciences (NCMS) program in the early 1990's funded initially by Defense Advanced Research Projects Agency (DARPA) and a later follow-on by NIST ATP. It had an objective of modeling manufacturing resource data. (For more information visit http://www.nist.gov/rrm)

Of these programs the STEP-NC Program has very high visibility and indeed is demonstrating the viability of driving NC Controllers using STEP "AP238" (an implementation of ISO 14649) via an Open Modular Architecture Control (OMAC) Application Programming Interface (API) to an NC Controller. SCRA's implementation and execution of the TACOM N-STEP Program will complement/supplement the STEP-NC activity.

2.8.2 Shipbuilding Suite

The principal STEP Application Protocols addressing the Shipbuilding Industry are AP's 215, 216, 218, 226, and 234 and supplemented by AP212, AP227 (Ed. 2) (replaced AP217) and ISO 13584 (PLIB)). A strong driver for the development and implementation of these standards has been the Navy/Industry Digital Data Exchange Standards Committee (NIDDESC)
(Much of the material in this section came from the ISO TC184/SC4/WG3/T23 web site: http://www.nsnet.com/NIDDESC/t23.html and the NIDDESC web site – http://nsnet.com/NIDDESC/niddesc.html.)

There has been extensive International cooperation and participation under the leadership of NIDDESC, EMSA, JECALS, KRISO, and KS-STEP (more details below) where

EMSA = European Marine STEP Association,
JECALS = Japan EC/CALS,
KRISO = Korean Research Institute of Ships and Ocean engineering,
KS-STEP = Korean Ship – STEP,
NIDDESC = Navy/Industry Digital Data Exchange Standards Committee.

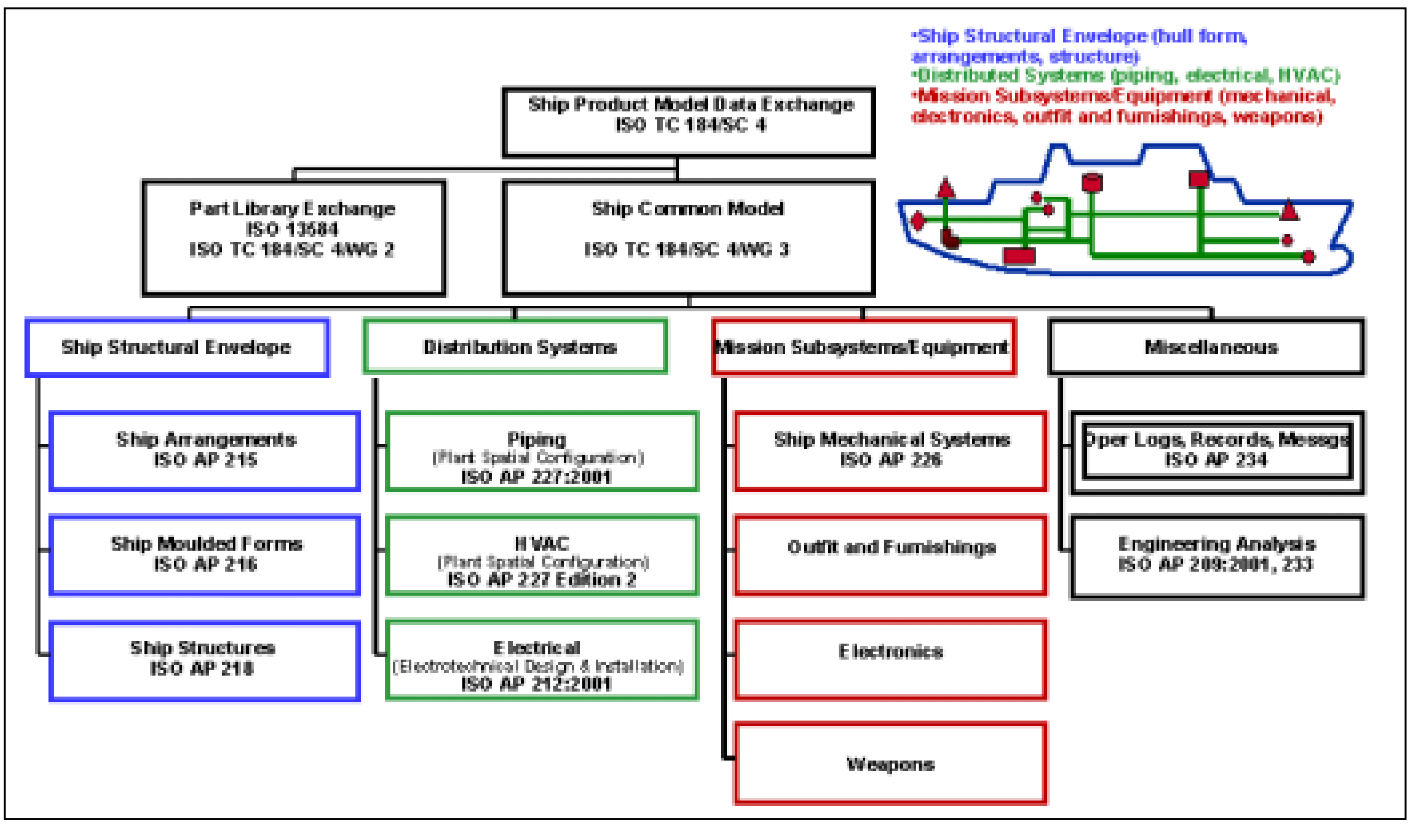

Figure 7: Ship STEP Product Model Data Exchange

Note: Earlier predecessors of the STEP Shipbuilding Application Protocols were the NIDDESC Specifications. These are noted by the NSRP number of the related specification. These specifications provided the "starting points" for many of the Shipbuilding STEP AP's.

AP 215: Ship Arrangements (See 2.7.3) (Corresponds to/replaces NSRP 0429 Version 2.0, 1999)
Specifies the information requirements for the exchange of product data representing a ship's internal subdivision information between different organizations with a need for that data. Such organizations include ship owners, design agents, and fabricators. This AP has been developed to support the shipbuilding activities and computer applications associated with the Functional Design, Detail Design, and Production Engineering life cycle phases for commercial or military ships. The types of design activities and computer applications supported include naval architectural analyses (e.g., Damaged Stability, Compartmentation and Access, and Floating positions), structural analysis, interference analysis, and weight analysis.

AP 216: Ship Moulded Forms (See 2.7.4) (Corresponds to/replaces NSRP 0429 Version 2.0, 1999)
Specifies the information requirements for the exchange of ship moulded forms and related hydrostatic properties. The AP supports hull moulded forms and moulded forms for structures internal to the ship, and supports surface and underwater ships for commercial and military use.

AP 217: Ship Piping (Significant overlap with AP227 – Replaced by AP227 (Edition 2)) (See 2.6.11) (Corresponds to/replaces NSRP 0424 Version 2.0, 1999 (Piping) and NSRP 0426 Version 1.0, 1995(HVAC))
Specifies the information requirements for the exchange of ship piping functional design, detail design, production engineering, fabrication, assembly and testing.

AP 218: Ship Structures (See 2.7.5) (Corresponds to/replaces NSRP 0429 Version 2.0, 1999)
Specifies the information requirements for exchange of ship structural systems data for ship predesign, design, production, and inspection/survey. Product definition data pertaining to the ship's structure includes: hull structure, superstructure and all other internal structures of commercial and naval ships.

AP 226: Ship Mechanical Systems (See 2.7.10)
Specifies the information requirements for exchange of ship mechanical systems information. This includes the exchange of information related to deck, propulsion and other mechanical systems in a ship product model. Connectivity between components and systems geometry, materials, topology and tolerances, noise, vibration and shock characteristics, component/system life cycle and operational history are part of the product model. Contains quality assurance information on availability, reliability, and maintainability.

AP234: Ship Operational Logs, Records, and Messages - New Work Item (NWI) (1999)" (See 2.7.15 and http://www.nist.gov/sc4/step/parts/part234/current/readme.txt)
This part of ISO 10303 specifies an application protocol (AP) for the exchange and archiving of data that are generated during the operation of commercial ships. The data may be collected in

logs, messages, and records, and may be archived on board or exchanged between ship and shore via satellite communication. This Application Protocol supports surface ships commercial use.

AP236: Furniture product and project data (See 2.7.17)
The Shipbuilding STEP Team has been working with the "Furniture STEP (FUNSTEP)" Team to integrate the Shipbuilding requirements for "Ship outfit and furnishings" (contained in NSRP 0428 Version 1, 1995) into AP236. This work is on-going.

Distrbution System APs (from NIDDESC Website) (See Figure 7 above.)

ISO 10303 contains other product model data exchange standards that are not ship specific but that can be used for ship product model data exchange in commercial processes. The approved distributed system APs are the most important standards. ISO 10303 AP 212:2001 supports electrical data exchange, and ISO 10303 AP 227:2001 supports piping data exchange.

AP 212 (ISO 10303-212:2001) provides exchange capbabilities of components, transmission and controls in equipment and facilities. AP 212 provides electrical design and installation information for electrical cables and harnessing. (See 2.6.7)

AP 227 (ISO 10303-227:2001) provides the ability to exchange basic piping information. An Edition 2 is addressing additional piping information for ship conformance classes **and** HVAC information needs. AP 227:2001 provides data needed to support functional design, detail design, production engineering, fabrication, assembly and testing. (See 2.6.11)

Extension of ISO 10303-227 to include the representation and exchange of piping configurations and properties specific to support prefabrication and inspection of piping assembled in a shop and the installation of the prefabricated piping. This activity extends AP 227 to support information about HVAC (heating, ventilation, and air-conditioning) components and systems and adding refinements to make AP 227 more useful to the general building and shipbuilding industries.

AP 227 Edition 2 adds ship, fabrication, HVAC, and Cableway information. This application protocol defines the context, scope, and information requirements for the exchange of design and layout information for a process plant, plant systems, ship systems, system components and equipment between different agents over the life cycle of the facility and specifies the integrated resources necessary to satisfy these requirements. The reasons for exchanging this information include:

- exchange of requirements from an owner to an engineering firm;
- exchange of cableway, HVAC, piping and equipment designs between a design engineer and a system engineer;
- exchange of cableway, HVAC, piping and equipment designs between a design engineer and a fabricator;
- exchange of changes to cableway, HVAC, piping and equipment designs between a design engineer and a system engineer or a fabricator;
- exchange of piping fabrication information, fabricated piping inspection results and installation information between engineering, fabrication and construction firms;

- integration of designs created by different engineers;
- detection of physical interferences of systems and components with components of other systems;
- exchange of cableway, HVAC and piping installation information between engineering and construction firms and with owner organizations;
- exchange of as-built facility and system configurations among owners, engineering firms and construction firms.

NAVSEA and the Defense Logistics Agency are developing user's guides for AP 227 Edition 2. NSRP 0424 Version 3.1 will address piping and NSRP 0216 Version 2.0 will address HVAC and Cableways.

PLIB

ISO 13854 (Parts Libraries) is a companion standard to STEP. Before a product model exchange can successfully take place a successful part library exchange is necessary. A successful PLIB standard is critical to the ship APs. (See APPENDIX D for detail on the scopes of the ISO 13854 parts.)

From the T23 Website (http://www.nsnet.com/NIDDESC/t23.html**)**

"There are several ship industry groups that have been formed to accelerate the development of the ship APs. Four of these groups have signed a Memorandum of Understanding (MoU) that forms a baseline for international cooperation for the development and testing of the ship APs.

The Europeans are coordinating their STEP ship efforts with the European Marine STEP Association (EMSA). EMSA was founded in 1994 and is a membership-based organisation of enterprises from the maritime industry. The purpose of EMSA is to improve the productivity of its members by promoting the development, implementation, and use of STEP. EMSA co-ordinates projects that involve its members and that serve this purpose.
Contributions to the standardisation as well as the implementation of the marine Application Protocols (APs) in ISO TC 184/SC 4 are harmonised. EMSA has ship AP demonstration projects underway.

The US is coordinating STEP ship efforts in the Navy/Industry Digital Data Exchange Standards Committee (NIDDESC). NIDDESC was formed in June 1986 as a cost-sharing venture, between private firms and government organisations. NIDDESC has the charter to develop a US marine industry consensus on product model data transfer and to ensure that national and international standards such as IGES and STEP support the marine industry data transfer needs. The NIDDESC efforts initially documented US requirements for ship product model data exchanges. The original US requirements are available in the NSRP repository. Search on the key word "NIDDESC" for the specifications in the NSRP document center. NIDDESC has two projects underway. One is demonstrating ship APs for STEP, Evolution of STEP (ESTEP), and the other is demonstrating PLIB, PLSSPD. The ESTEP demonstrations will result in updates to the NIDDESC models in the NSRP document library. Version 2.0 documents can be found for the ship structural envelope APs (arrangements, moulded forms and structure) as National Shipbuilding Research Project (NSRP) 0429.

The Japanese coordination is done in the Japan Marine Standards Association (JMSA) organization. JMSA is the unique, non-profit organization in Japan that collectively deals with the affairs related to standardization work in the field of ships and marine technology.

The principal activities of JMSA are:
(1) Development of the draft Japanese Industrial Standards (JIS),
(2) International standardization activities,
(3) Publicity of JIS (Ship division) and
(4) Activities related to the quality system registration scheme.

The STEP/ship AP committee, consisting of experts from Japanese shipbuilders, classification society and others, is one of the committees of JMSA. The main activity of this committee is the participation in ISO TC 184/SC 4/WG 3/T 23 meetings and investigation of ship AP documents.

The Korea STEP Center, founded in April, 2000, is the non-profit organization in Korea that promotes the use and development of STEP technology among various industries in Korea. The Korean Research Institute of Ships and Ocean Engineering (KRISO) is coordinating the Korea STEP Center organization. As a part of its activity it includes the effort for the development of ship STEP technology and support to shipbuilding industries in Korea. It also assists the national standardization efforts about industrial data. The Korea STEP Center is helping document test requirements for AP 218.

During the past several years and currently, numerous prototypes have been and are being developed in the Shipbuilding STEP arena and many demonstrations have taken place and are planned for the near term future. Some of these activities are listed below."

STEP Shipbuilding Prototypes and Demonstrations:

- Computational Fluid Dynamics in the Ship Design Process (CALYPSO) http://www.oss.dk/resdev/internationalprojects/calypso.htm
- Electronic Data Interchange for the European Maritime Industry (EDIMAR) (ESPRIT – AP226) http://www.biba.uni-bremen.de/projects/edimar/summary.html
- MariTech STandard for Product model exchange (MariSTEP) http://www.intergraph.com/federal2/projects/step/
- Evolution of STandard for Exchange of Product model data (ESTEP) an NSRP ISE Project http://www.nsrp.org/projects/slide_shows/isec.pdf
- Models for Operational Reliability, Integrity, and Availability Analysis of Ship Machinery Systems (MOSys) (Brite/EuRam Project No. BE97-4429) (AP226) http://www.biba.uni-bremen.de/projects/mosys/ or http://www.mosys.org/
- Harvest (NSRP) (AP215, AP216, AP218 Standardization) http://www.nsrp.org/projects/harvest.pdf

- ♦ Korean Ship Project (Abstract Test Suite/Test Case development for AP218) KRISO research institute, KAIST university, KR classification society, DAEWOO shipyard and SAMSUNG shipyard.
- ♦ Leading Edge Advanced Prototyping for Ships (LEAPS) – NSWC-Carderock developed environment for integrating modeling and analysis tools.

2.8.3 Process Plant Suite

NIST has had a leadership role in developing the Process Plant (and Architecture, Engineering and Construction (AEC)) AP's with extensive international cooperation and participation. The primary AP's for Process Plants are AP's 221, 227, and 231. The primary AEC AP (to date) has been AP225.

AP221 (CD) **- Functional data and their schematic representation for process plant** (See 2.7.8)- This AP addresses functional data and some physical data for plant items and systems. Within the scope are schematics (e.g., Piping and Instrumentation Diagrams (P&ID) and data sheets); standard data for piping, values, vessels, instrumentation and some equipment; and data repository concepts.
(See http://www.stepcom.ncl.ac.uk/epistle/standards/index.html and http://www.uspi.nl)
"AP221 was balloted and approved as an ISO Committee Draft in 1997. Subsequent development has been delayed by the need for harmonization with the POSC Caesar product model. This harmonization work was carried out by the EPISTLE Data Modelling Group, consisting of experts nominated by PISTEP, POSC Caesar, and USPI-NL. The Data Modelling Group produced the EPISTLE Core Model version 3 and ISO/CD 15926-2 as interim deliverables of this harmonization process and the EPISTLE Core Model version 4 as the final deliverable. Version 4 is being published for international balloting as ISO/DIS 15926-2 and forms the basis for the Application Reference Model of the Draft International Standard version of AP221. The Draft International Standard of AP221 (was) expected to be completed and published before the end of 2001. This will make use of STEP application modules; a draft version of the modular form of AP221 was presented at the ISO TC184/SC4 and WGs meeting in San Francisco (June 2001)."
ISO 18876-1 Architecture overview and description
ISO 18876-2 Integration and mapping methodology

AP227 (IS)**- Plant spatial configuration** - (See 2.6.11) - The emphasis of this AP is on piping design. It includes physical and functional characteristics and references to specifications and stream design cases.

AP231 (CD)**- Process design and process specifications of major equipment** (See 2.7.13)- The scope of this AP includes process simulation, unit operations, and the conceptual design of major process equipment. (Currently Inactive)

& Related AP's:

AP212 (IS)- **Electrotechnical design and installation** - IS (See 2.6.7)

AP225 (IS)- **Building elements using explicit shape representation** – (AEC)(See 2.6.10)

AP228 - Building services: heating, ventilation, and air conditioning - (AEC) Withdrawn

AP230 - Building structural frame: steelwork (See 2.7.12)- (AEC) Withdrawn due to lack of resources - (AP230: Building structural frames: Steelworks. The baseline for AP230 development is CIS - the CIMsteel Integration Standards, developed by the Eureka 130 CIMsteel project. A simplified version of CIS/AP230 is being adopted in Finland by the SteelBase project.)

Projects/Prototype Implementations (with AP's addressed):

- EPISTLE - European Process Industries STEP Technical Liaison Executive (AP221)
- POSC/Caesar - development of "STEP-like" standards in the oil and petrochemical industries
- SPI-NL - Standard for Plant Information in the NetherLands
- pdXi - process data eXchange institute (AP231)
- PlantSTEP - (NIST, Bentley, Dassault, Intergraph) (AP227)
- PIEBASE - Process Industry Executive for achieving Business Advantage using Standards for data Exchange (AP221, AP227, AP231)
- ProcessBase - (ESPRIT)- (AP221)
- PIPPIN - The PIPPIN Project (Pilot Implementation of Process Plant Information warehouse) is a collaborative project under the EC's ESPRIT IV programme. The partners include BP, Brown and Root, EuroSTEP, Framatome, ICI, ICS, Shell and Quillion. The project objective is to build a STEP compliant data warehouse for process plant engineering data using the STEP (ISO 10303) Standard.
- PISTEP is a consortium of UK companies in the process industries. It aims to increase the competitiveness of the UK process industry by improving engineering information management throughout the lifecycle and the supply chain. This is being achieved by the use of information technology and international standards.
- Eureka CIMsteel Project (AP230) (AEC & Process Plant) – 40+ collaborators in eight countries (Austria, Denmark, Finland, France, Italy, the Netherlands, Sweden & the UK)

2.8.4 Electrical/Electronics Suite

The electrical/electronic suite of STEP standards is administered jointly under the International Organisation for Standardisation (ISO) and the International Electrotechnical Commission (IEC). Currently that subset consists of AP210 (Electronic Assembly, Interconnect, and Packaging Design), AP212 (Electromechanical Design and Installation), and AP220 (Process Planning, Manufacture, and Assembly of Layered Electronic Products).

AP210 (IS) **- Electronic Assembly, Interconnect and Packaging Design** – (See 2.6.6)
AP212 (IS) **- Electrotechnical Design and Installation** - (See 2.6.7)
AP220 - Process Planning, Manufacture, and Assembly of Layered Electronic Products - (See 2.7.7) Currently inactive (i.e., withdrawn), but it is expected to be re-initiated in the 2002/2003 timeframe now that AP210 has been published as an IS.

Each of these AP's has been piloted in programs such as

- Pre-Competative Advanced Manufacturing Program (PreAMP) (AP210, AP220),
- Team Integrated-Electronic Response (TIGER) (AP210, AP220),

- a research program on raw materials and advanced materials (Brite EuRam) (Siemans) (AP212), and
- Rapid Acquisition of Manufactured Parts (RAMP) (AP210, AP220),

These pilots were performed while the AP's were under development to exercise, enhance, and validate their capabilities and robustness. Industry-wide consortia such as PDES, Inc. (based in the United States) and ProSTEP (based in Europe) have memberships committed to the development and implementation of STEP.

The PreAMP and TIGER programs were managed by SCRA's Advanced Technology Institute (ATI). The PreAMP program was a National Institute of Standards and Technology (NIST) Advanced Technology Program (ATP) funded project that addressed standards-based concurrent design processes and tools for printed circuit assemblies (PCA's). The TIGER program dealt with deploying cost effective, collaborative electronic commerce for PWB's and PWA's. TIGER was funded by the Defense Advanced Research Program Agency (DARPA).

A system for On-demand manufacturing of Printed circuit assemblies Using STEP (OPUS) (also known as On Demand Electronics Logistics Support (ODELS)) has been a "work in progress" for the last three years by Team SCRA. (See Document 11 in Appendix A.) It leverages the ISO STEP standards and the successes of the RAMP, PreAMP, TIGER, and STAMP Programs. The web-based OPUS/ODELS architecture integrates EC/EDI concepts with the robust technology of STEP-based applications to provide a powerful tool for customer/supplier interaction. It will provide tools to exchange product data among CAD/CAE systems, to reengineer product data, to evaluate data for manufacturability, to process plan the product, to negotiate changes in the product, and to process RFQs, bids, and awards. OPUS/ODELS will enable dramatic reductions in the time and cost to obtain electronic parts by allowing customers and PCA suppliers to utilize "Ready To Use" product data in a web-based environment.

OPUS/ODELS uses STEP to:
1. describe all aspects of an electronic assembly throughout its lifecycle (AP210),
2. describe the functional capabilities of the equipment in a manufacturing facility and the process plan for producing the product in a specific facility or facilities (AP220), and
3. provide a framework in which product structure and configuration management data is captured (AP232).

This Research and Development project (funded through the Defense MicroElectronics Activity (DMEA)) has resulted in development of a non-trivial Web-based prototype of the capability to use the DCVE to generate a complete 3D STEP AP210 representation of the 3D assembly of a PCA.

The STEP Electrical/Electronics Suite provides the description of all aspects of an electronic assembly throughout its lifecycle (AP210), and the description of the functional capabilities of the equipment in a manufacturing facility and the process plan for producing the product in a specific facility or facilities (AP220). In addition to the Electrical/Electronics Suite, AP212 fits into numerous other application domains such as process plant, building construction, and transportation systems.

Projected AP210 Implementations:

- ♦ Mentor Graphics has a commercially available AP210 Translator that was developed by International TechneGroup, Inc. (ITI), and it is now planned that it will be supported and marketed by LKSoft.
- ♦ Cadence – Allegro Designer/Allegro Expert
- ♦ Zuken-Redac's Freedom System (a 3D CAE System) – There has been some discussion about a PDES, Inc. initiated activity to develop an AP210 Translator starting in 2002.
- ♦ Eagle (a PC-based CAE System)
- ♦ LKSoft – a STEP Tool developer

2.8.5 Systems Engineering

AP233 is being developed as a Publicly Available Specification (PAS) "Reference Model for Systems Engineering" with ISO number PAS/WD 20542. A Working Draft (and a draft Abstract Test Suite (ATS)) is available at http://www.sedres.com/documents/pas/Index.htm. It is expected that PAS 20542 will be withdrawn within 3 years of publication and be replaced by ISO 10303-233. (See 2.7.14)

A new and highly visible STEP development activity is addressing Systems Engineering (SE). It is an extension of the work started in the European Systems Engineering Data Representation and Exchange Standardization (SEDRES) Project. This activity addresses another stage of the product lifecycle. (See http://www.sedres.com/ap233/sedres_iso_domains.html)

The following three (3) figures depict the intent and scope of STEP AP233 (Systems Engineering) and how it fits into the overall STEP Architecture. SE domains in AP233 will include:

(1) requirements for elicitation & analysis and test definitions;
(2) functional design supporting data description, function description behaviour description and object oriented design;
(3) physical design addressing topological architecture definition and supporting function component mapping;
(4) graphical representation and layout;
(5) traceability management;
(6) configuration management; and
(7) industry processes including risk management, justification management, documentation support, workflow definition linkage, approval support, person allocation, date allocation, and effectivity management.

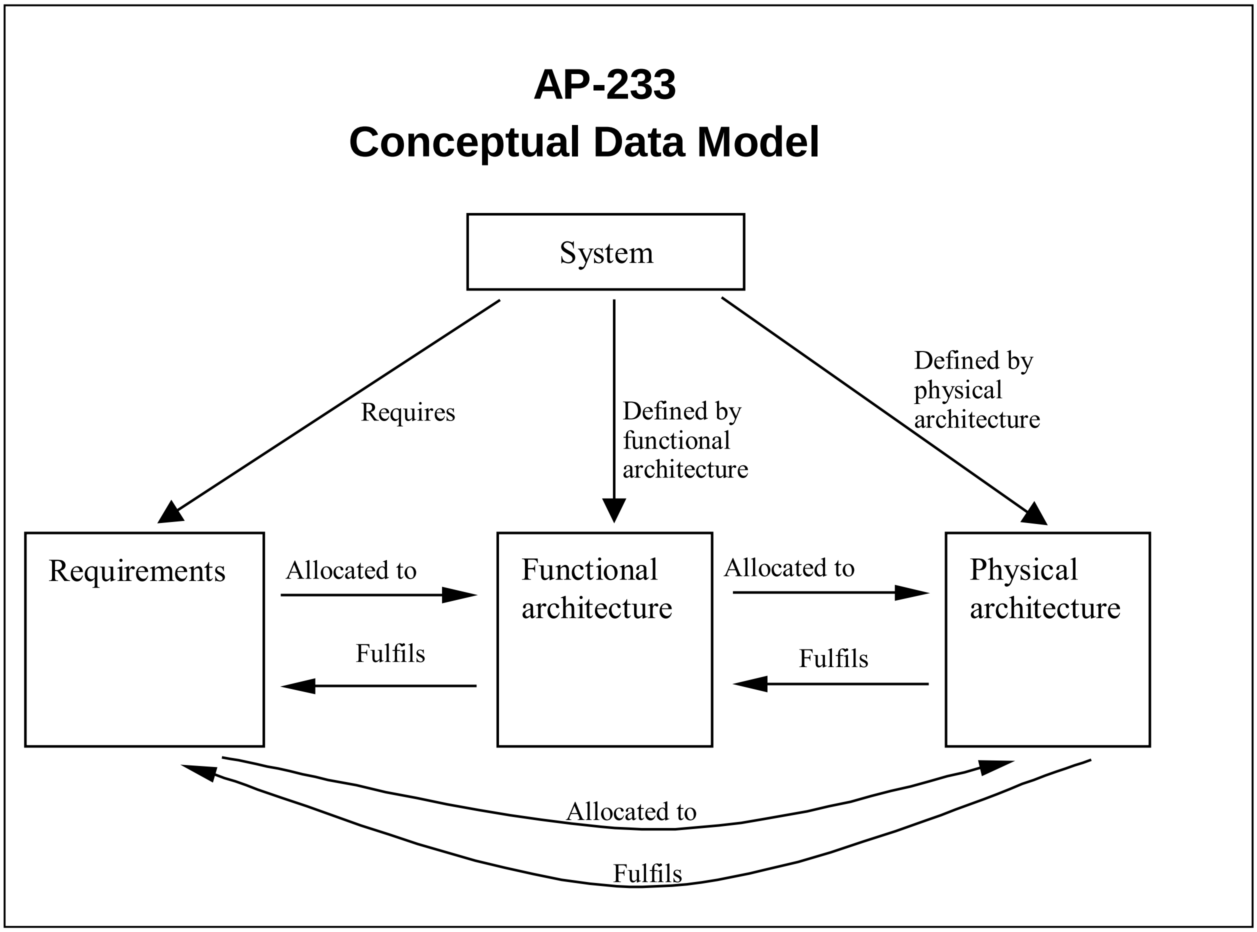

Figure 8: AP233 Conceptual Data Model

The diagram below illustrates the interaction of various STEP Application Protocols in an industrial framework environment.

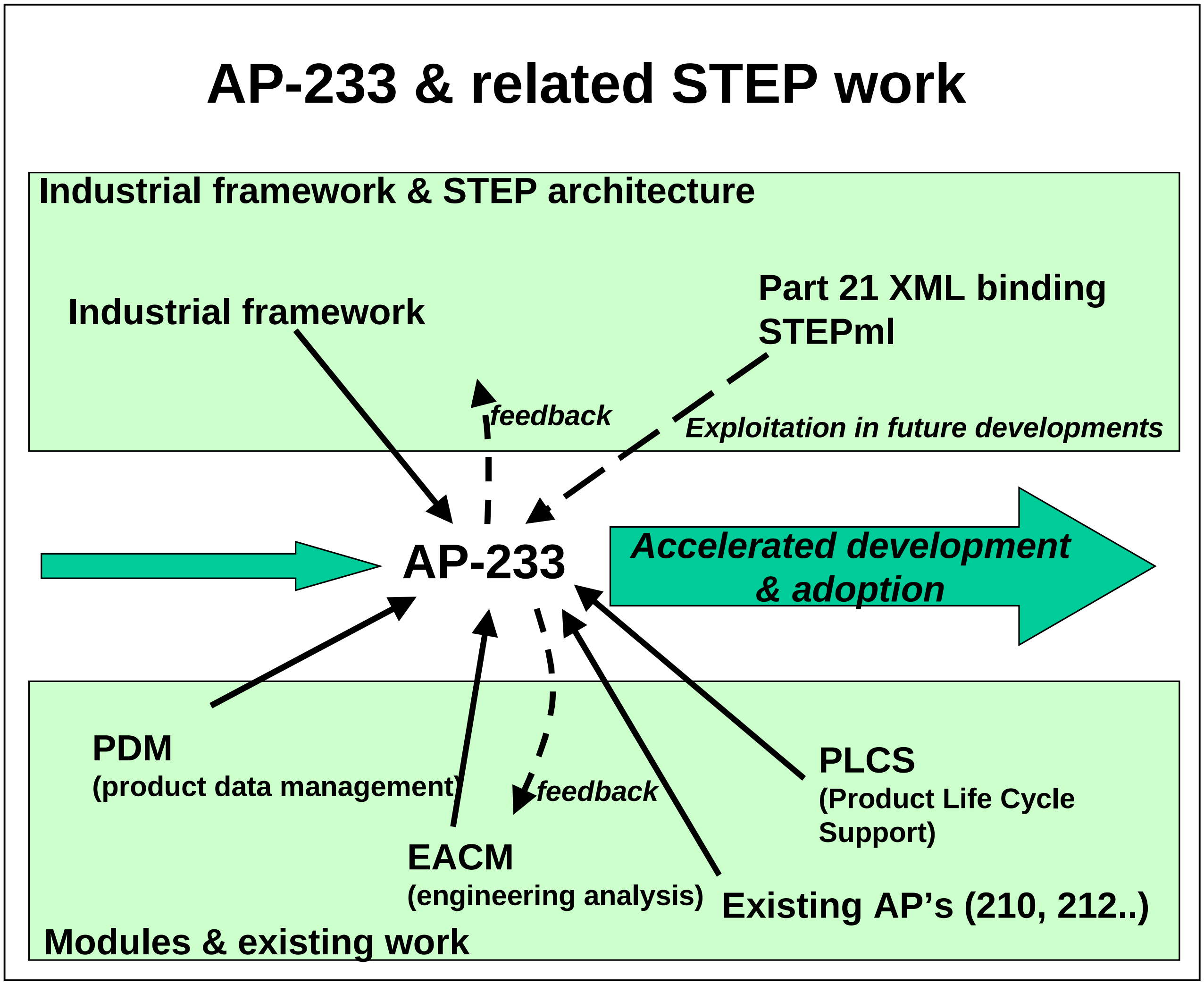

Figure 9: AP233 and Related STEP Work

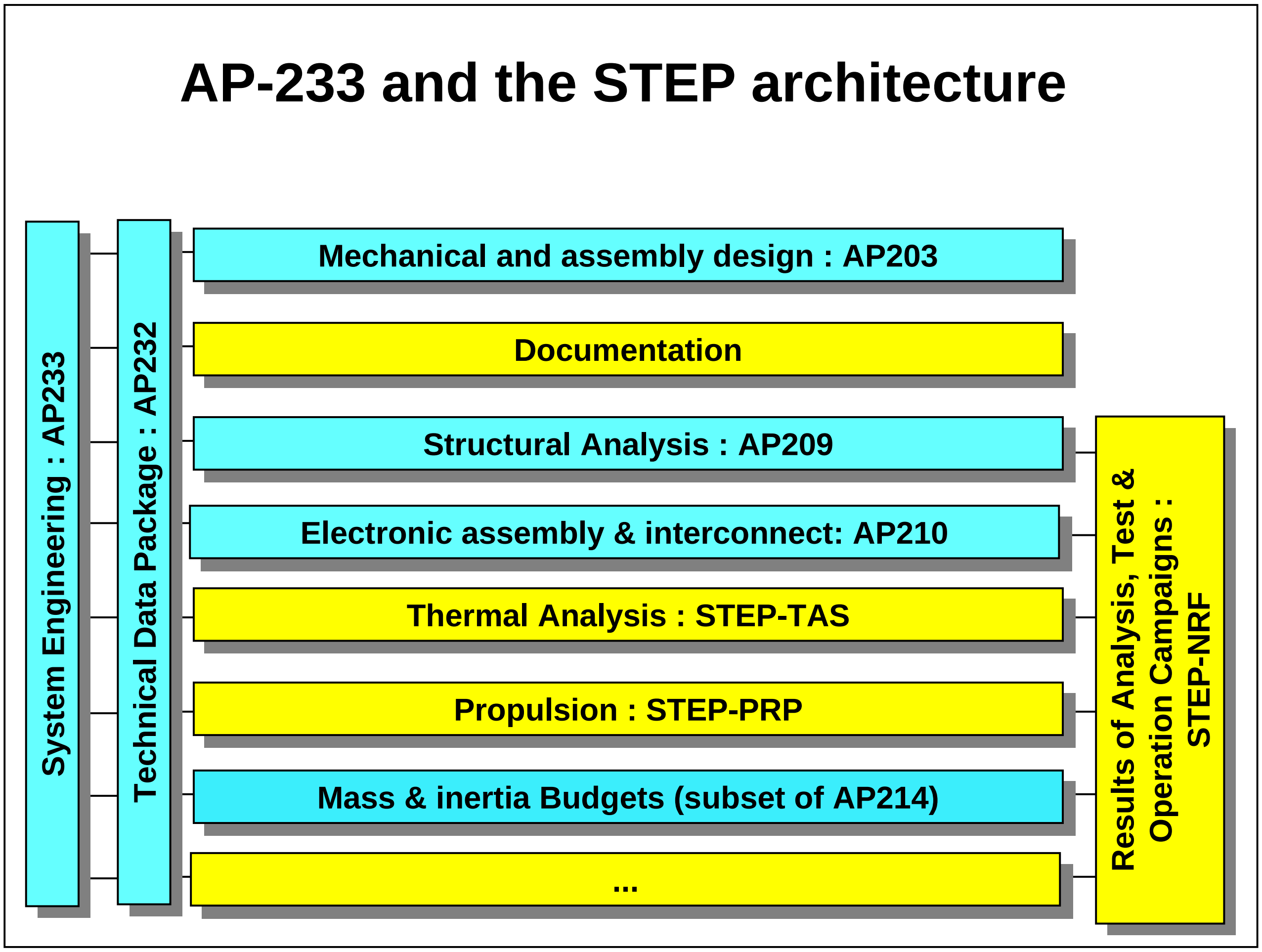

Figure 10: AP233 and the STEP Architecture

2.8.6 Engineering Analysis Core Model

The following information is from **The Engineering Analysis Core Model – A 'plain man's guide'** (See Document 19 in Appendix A and http://pdesinc.aticorp.org/ (PDES Inc.'s Public Website – STEP Capabilities – Engineering Analysis))

"(T)he Engineering Analysis Core Model (EACM) … defines the architecture of systems for engineering analysis information, and the interfaces between them.

The EACM is concerned with management issues, including:

- the versioning and configuration management of engineering analysis data;
- the archiving and exchange of engineering analysis data; and
- the audit trail links between engineering analysis data and the processes that create them.

The EACM is also concerned with technical issues, including:

- the storage of the definition of an engineering problem as well as the details of a particular approach to its solution;
- the transfer of information between different disciplines (e.g. structural, CFD (Computational Fluid Dynamics), thermal) and between different representations (e.g. different meshes - structured and unstructured, h-refinement and p-refinement); and
- the use of test data in analysis."

"The EACM has three key aspects:

- the management of engineering analysis information alongside all other information concerned with the design of a product …;
- the linking of all engineering information to the activity that created it, whether a design decision, analysis calculation or test …; and
- the holding of information about the properties of a product, including fields that vary with respect to space and time, in a form that can be used by any system for any calculation ...

These three aspects taken together mean that the EACM is a bridge between three different worlds:

- CAD and PDM, where systems for managing the design process have developed from Drawing Office Registries;
- the workflow and project management, where concerns range from time sheets at one end to the auditing of a certification process at the other;
- leading edge analyses, with problems such as the transfer of information from a finite difference CFD code to a p-refinement structural code."

"The EACM consists of modules that provide capabilities as follows:

- the data management of information about a product, its environment and its usage scenarios (This capability is provided by interfaces to the PDM modules...);
- the definition of the properties of a product - as they exist for a particular state of the product, and as they vary during a particular usage of the product;
- audit trails for the source of property information, and indicators for the quality of property information;
- a range of mathematical techniques for the description of properties that are fields varying with respect to position or time - these include descriptions with respect to structured and unstructured analysis meshes, and with respect to the parameter spaces used for product geometry."

The initial EACM STEP Parts are described in the NWI for Fluid Dynamics. The parts were registered with ISO as AWI's in August 2001. The documents can be referenced at: http://www.nist.gov/sc4/nwi_pwi/nwi/step/fluid_dyn/doc

The new work item defines a standard for the sharing, exchange, and storage of fluid dynamics data. The information within scope will include digital flow field data, surface data, and integrated data from three types of sources: (1) analysis and computation, (2) ground test (e.g., wind tunnel test), and (3) flight test. The first edition will focus on data related to analysis and computation. and consists of the following four parts (See 2.7.18):

- 10303-237, Application Protocol: Computational fluid dynamics
- 10303-110, Integrated Application Resource: Computational fluid dynamics data
- 10303-52, Integrated Resource: Mesh-based topology
- 10303-53, Integrated Resource: Numerical analysis

The EACM Suite supplements and expands upon AP209 which is already an International Standard (See 2.6.5)

2.8.7 Product Life Cycle Support (PLCS)

Another area of high visibility in STEP is Product Life Cycle Support (PLCS). This activity is still in its early stages, but has significant resources committed to its success including an international consortium, PLCS, Inc., founded in 1999. Their primary emphasis is to address the Support/Maintenance stage of the product life cycle utilizing the STEP Architecture. Figure 11 shows the scope of the PLCS activity. ((See 2.7.20 and http://www.plcsinc.org/)

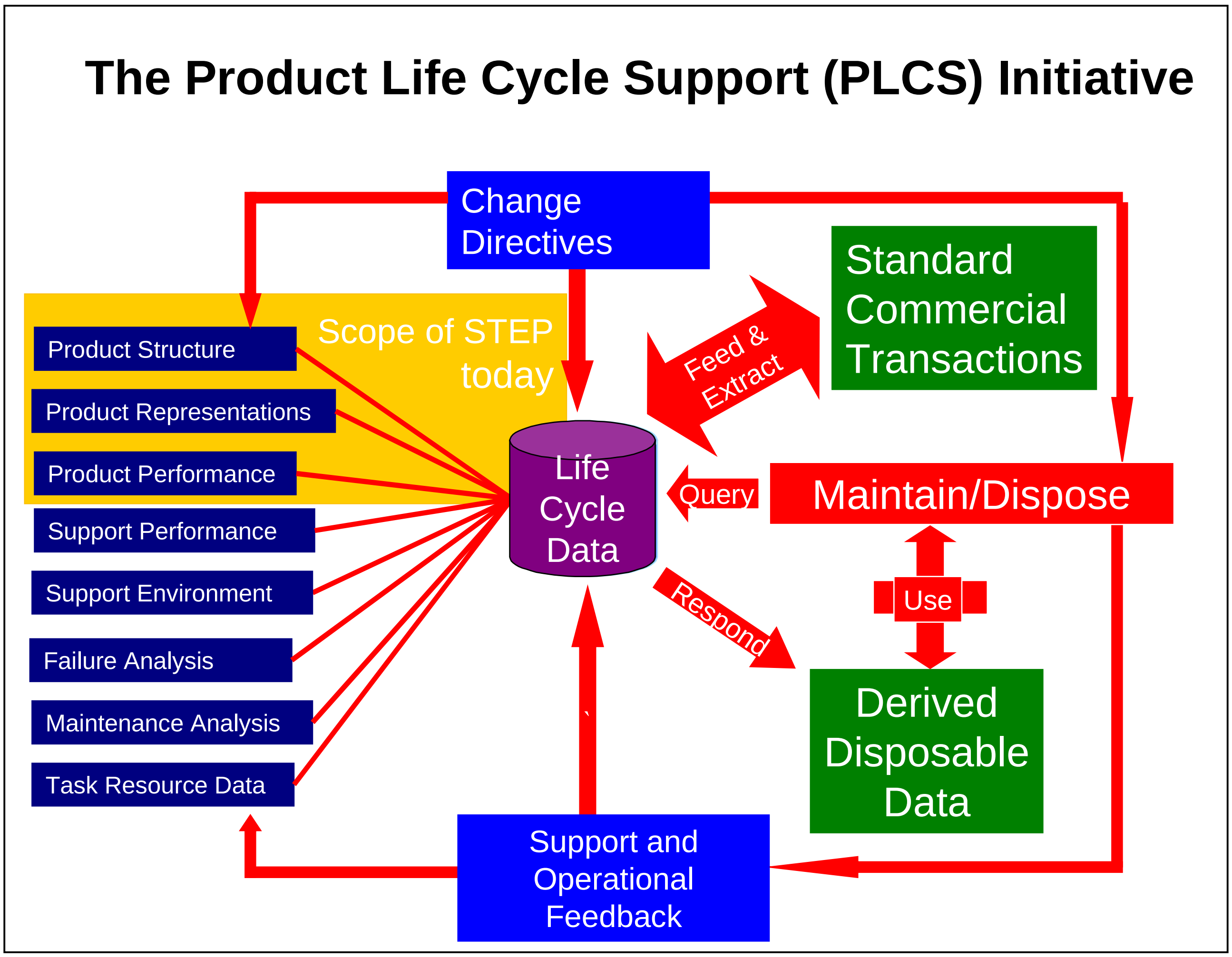

Figure 11: Product Life Cycle Support

3. Other Product Data Exchange Specifications & Standards

Other "de facto", national, international product data exchange (PDE) standards exist and have been widely implemented. Many were originally developed to address 2D draughting (e.g., IGES, SET, VDA, DXF, DWG). Others such as EDIF, IPC, and Gerber were developed to address "point" solutions for different aspects of the Electrical/Electronic design process (e.g., schematic, netlist, photo plot, …).

There are certainly instances where these PDE solutions are appropriate. There are other instances where perhaps direct translation is most appropriate. Most of the major vendors provide multiple PDE solutions/tools, and some provide PDE translation services. Several web sites are cited for further discussion on the use of other PDE formats.

This section identifies most of the "popular" PDE specifications and standards and provides a table of Vendor STEP and other PDE capabilities. There is also some discussion about direct translators, translation service centers, STEP tools, and solids modeling kernels for some of the major CAD/CAM systems.

Other PDE Standards:

IGES - Initial Graphics Exchange Specification --- ANSI Standard (Latest Version 5.3 - 1997) - Initially (ANSI Y14.26M-1981) addressed 2D and 3D drawing data, later added Solid Model data (CSG & B-Rep), Piping, Drafting and Electrical Subsets/Application Protocols also now exist. (Virtually, every CAD/CAM vendor has an IGES translator for their system.)

SLC - Rapid Prototyping - Stereolithography - 3D Contour based data format

STL - (3D Systems, Inc.'s Stereolithography Interface Specification (SIS) - Public Domain) - 3D vectorized/triangulated data - Widely used "de facto" industry standard.

DXF - (AutoDesk/AutoCAD Proprietary - Public Domain) - Widely used "de facto" industry standard.

DWG - (AutoDesk/AutoCAD Proprietary - Public Domain) - Widely used "de facto" industry standard.

ACIS (.sat) - (Spatial Technologies Proprietary - Public Domain) - A Solid Modeling System developed and marketed by Spatial Technology, Inc. - ACIS is the solid modeling kernel for numerous commercial CAD systems (e.g., AutoCAD, Mechanical Desktop, CADKEY, IronCAD, …) "It supports 3D surfaces and solids and is based upon NURBS and B-rep solid modelling."

ParaSolid (.xmt, .x_t, eXT) - (UGSolutions - Proprietary) - A Solid Modeling System developed and marketed by Unigraphic Solutions - Parasolid is the solid modeling kernel for numerous commercial CAD systems (e.g., Unigraphics, SolidEdge, SolidWorks, …) "It supports 3D surfaces and solids and is based upon NURBS and B-rep solid modelling technology."

VDA - Verband der Deutsche Automobilindustrie - German DIN Standard

VDA-IS (1.0) - "IGES Specification - A subset (primarily for the exchange of drawings) of IGES used in the German Automotive Industry (DIN 66

301) - "standard to exchange two-dimensional basic CAD geometry and dimensions."

VDA-FS (2.0) - VDA/Flachen Schnittstelle- "neutral format for exchanging surface data between different CAD systems. Developed in Germany by VDA." (Includes/addresses trimmed surfaces)

SET - Standard d'Exchange et de Transfert - French AFNOR Standard (Z68-300) - Initially (1985) - Very much like IGES in content with a different, more efficient file structure. Has added coverage of Finite Element Modeling (FEM), Numerical Control (NC) and Solid Modeling (CSG, Advanced B-Rep, and Facetted (polyhedral) B-Rep) - Developed by Aerospatiale. Maintained by GOSET.

JEDMICS - U.S DoD repository for archiving Technical Data Packages - They are primarily stored in CCITT Group 4 Raster format, but JEDMICS is capable of storing virtually any format.

There is a nice discussion on IGES/SET/VDA and STEP @ http://www.theorem.co.uk/docs/standard.htm (from which several of the above descriptions were taken) and http://www.ukceb.org/step/pages/stpgolb1.htm

A report from the GM STEP Testing Center comparing STEP AP203 and IGES for Surface and Solid models can be found in the PDES, Inc. Public Archives @ http://pdesinc.aticorp.org/whatsnew/archives/step_overview.html

Electrical/Electronics Product Data Exchange Standards:

EDIF- ANSI/EIA (& IEC) Standard (Versions 2 0 0,(ANSI/EIA 548:1988) 3 0 0 (ANSI/EIA 548: 1993 & IEC 61695-1:1995) & 4 0 0 (IEC 61695-2:2000) have numerous ECAD Implementations (primarily EDIF 2 0 0)) - including schematic & netlist data

IPC D35x (IEC 61182-1:1994) **-** ANSI (& IEC) Standard for electrical/electronic connectivity

Raster CCITT Group 4 --- An International Standard for raster data

Gerber (ANSI RS-274 X & D) **-** Widely used Industry "de facto" photo plot standard

VHDL (IEC 61691 Series) - ANSI/IEEE - Functional behavioral modeling language standard for electrical/electronic circuits

There are national and international standards; there are *de facto* and industry standards. They have varying levels of data coverage and acceptance. Typically, in the electrical/electronics domain, the Electronic Design Interchange Format (EDIF) has been used for the schematic and netlist; the format of the Institute for interconnecting and Packaging electronic Circuits (IPC) has been used for board layout and connectivity; the Initial Graphics Exchange Specification (IGES) has been used for the mechanical structure of the board, and the Gerber photoplot format has been used for photo layout. EDIF, IPC, IGES and Gerber are American National Standards Institute (ANSI) standards. Each of these provide "point" solutions for electrical/electronic product data exchange (i.e., schematic to schematic, layout to layout, mechanical to mechanical, …). They do not provide an integrated approach to the entire lifecycle of the products. For years, there have been attempts to harmonize the electrical/electronic product data exchange standards with only a modicum of success.

AP210 addresses the design of electronic assemblies, their interconnection and packaging. Within its scope are the “as-required”, “as-designed” and “as-used” product information for the “in process” design and the “release” design. AP210 product data can be shared across several levels of the supply base and between design, analysis and manufacturing. AP210 provides a single data model which allows 3D component geometry, 2D bare board artwork, abstract behavioral models, and electrical network connections to be described and interrelated (i.e., all the information needed to manufacture a PCA).

4. Commercial Products and Services

4.1 CAD/CAM/CAE Vendor STEP Capabilities

The following table provides a summary of commercially available STEP translators for most of the major CAD/CAM/CAE vendors and comments on some of their near term future implementation plans. Each of these vendors has some level of STEP AP203 and "AP214" translator. This table was compiled from survey inputs from the vendors and CAx-Implementor Forum presentations. The table represents a "snap shot" of the status of commercially available STEP Translators at this point in time. **All of these vendors have other translators as well (e.g., Direct, IGES, DXF, etc.).**

Vendor	AP203	AP214	Comments
Alias/Wavefront: Studio/Design Studio/Surface Studio/Auto Studio	cc 1a, 2a, 4a, 6a	cc 1, 2	
Alibre Design	cc 1a, 2a, 4a, 6a		cc 6a Certified
Autodesk: Mechanical Desktop	cc 1a, 2a, 4a, 6a +Colors, Layers, 3D Annotation modules & Groups	cc 1, 2 including Colors, Layers, 3D Annotation, & Groups	cc 6a Certified
AutoCAD 2000	cc 1a, 2a, 4a, 6a +Colors, Layers, 3D Annotation modules & Groups	cc 1, 2 including Colors, Layers, 3D Annotation, & Groups	
Inventor R2	cc 1a, 6a	cc 1, 2	
Bentley: Microstation J	cc 1a, 2a, 3a, 4a, 5a, 6a + Colors & Layers	cc 1 including Colors & Layers – Import, Export	AP227 - Prototype AP225 – Planned
Microstation Modeler/J	cc 1a, 2a, 3a, 4a, 5a, 6a + Colors & Layers	cc 1, 2 including Colors & Layers – Import, Export	AP203 via ACIS (cc6 = .sat)
Microstation(Parasolid Edition)	cc 1a, 2a, 3a, 4a, 6a +Colors		
CADKEY Corp: CADKEY 98	cc 1a, 2a, 4a, 6a	cc 2	
CNC Software: MasterCAM	(Import only) cc 1a, 2a, 4a, 6a	(Import only) cc 1	Export planned for Future
CoCreate: SolidDesigner	cc 1a, 2a, 4a, 6a	cc 1, 2	
Dassault Systemes & IBM: CATIA v4.2.2/v4.2.3	cc 1a, 2a, 3a, 4a, 5a, 6a + Color, Layers&Annotation modules	cc 1, 2* including Prototype Colors & Layers	cc 6a Certified Have AP227 (cc2)
CATIA v5	cc 1a, 2a, 3a, 4a, 5a, 6a	cc 1, 2	cc 6a Certified, Have AP227(cc2), Have AP 221 Prototype,
SolidWorks	cc 1a, 2a, 4a, 5a, 6a + Colors	cc 2*	cc 6a Certified

Vendor	AP203	AP214	Comments
T-Systems (formerly debis) COM/STEP (CATIA 4 & 5) COM/STEPorg (CATIA 4 & 5)	 cc 1a, 4a, 5a, 6a	 cc 1,2,3,4 cc 6	 AP202-cc 3,7,9,10 AP201, Separate Feature Modules cc 6 (PDM)-AP214
ITI: ACIS/STEP I-DEAS Mentorgraphics	 cc 1a, 2a, 4a, 6a cc 1a, 2a, 4a, 6a	 cc 1, 2 cc 1, 2	 See SDRC AP210 (cc4-9,14,17,23) (transferred to Boeing)
Knowledge Technology: KBO (v1.0 - ICAD 7.0)	 cc 1a, 2a, 6a		
LSC Group LOCAM	 cc 1a, 2a, 3a, 6a		 AP224 (IS) Postprocessor (In)
EADS Matra Datavision: Euclid Designer OpenCASCADE	 cc 1a, 2a, 3a, 4a, 6a cc 1a, 2a, 4a, 5a, 6a	 cc 1, 2 cc 1, 2	
McNeal Schwendler: Patran	 cc 1a,2a,3a#,4a#,5a#,6a (#=Import only)		 cc 6a Certified AP209 (cc's 1-8, 9,10)
PTC: Pro/ENGINEER 2000i[2] CADDS5 (Rel 10) CADDS5 (Rel 11)	 cc 1a, 2a, 4a, 6a + Colors, Layers, Validation Prop's modules & Groups cc 1a, 4a, 6a cc 1a, 2a, 4a, 6a	 cc 1, 2, 8 +external file ref. cc 1	 AP202 (In-cc 1-5, 8-10, Out 1, 5, 8,9) Dev'd by ITI Dev'd by PTC
SDRC: I-DEAS Artisan v7.0 (MS)	 cc 1a, 2a, 4a, 6a +Color & Validation Properties	 cc 1, 2	 ITI developed
STEP Tools, Inc.: ST- ACIS ST- Parasolid ST-Viewer v3.1 ST-Plan	 cc 1a, 2a, 3a, 4a, 6a + Color, Layer, Valid Prop's cc 1a, 4a, 6a + Color, Layer, Valid Prop's – cc 1,2,3,4,5,6+color Layers & Valid Prop's	 cc 1, 2, 9 cc 1, 2, 9 cc 1, 2, 9	Also AP203 with STL, GIF, JPEG, VRML & Part 21 -> XML ISO 14649/AP238 Prototype (See Notes after Table)
Surfware, Inc.: SurfCAM			No STEP Translator, Has ACIS translator, Could use an ACIS/STEP translator to import STEP AP203/AP214 files
Team SCRA: STEPTrans (Pro/E)	 cc 1a, 2a, 3a, 6a		 AP224 (IS) Preprocessor (Out)

Vendor	AP203	AP214	Comments
STEPPlan (ICAD)	cc 1a, 2a, 3a, 6a		AP224 (IS) Postprocessor (In)
Theorem Solutions:	+ Colors, Tags & Validation Prop's		
ACIS/STEP	cc 1a, 2a, 3a, 4a, 5a, 6a	cc 1, 2	.sat or .sab
Parasolid/STEP	cc 1a, 2a, 3a, 4a, 5a, 6a	cc 1, 2	.xmt or .x_t
CADDS4X	cc 1a, 2a, 3a, 4a, 5a, 6a	cc 1, 2	
CADDS5	cc 1a, 2a, 3a, 4a, 5a, 6a	cc 1, 2	cc 6a Certification
CATIA	cc 1a, 2a, 3a, 4a, 5a, 6a	cc 1, 2	Also AP209
Unigraphics	cc 1a, 2a, 3a, 4a, 5a, 6a	cc 1, 2	
I-DEAS	cc 1a, 2a, 3a, 4a, 5a, 6a		Master Series
SolidWorks	cc 1a, 2a, 3a, 4a, 5a, 6a		via Parasolid
SolidEdge	cc 1a, 2a, 3a, 4a, 5a, 6a	cc 1, 2*	via Parasolid
Autodesk Mech Desktop	cc 1a, 2a, 3a, 4a, 5a, 6a		
ICEM	cc 1a, 2a, 3a, 4a, 6a		
CADVerter			On-line Web-based Translation Service
UGSolutions:			
Unigraphics	cc 1a, 2a, 4a, 5a, 6a + Colors, Layers & Validation Prop modules	cc 1, 2 including Colors, Layers & Validation Prop's	cc 6a Certified,
SolidEdge	cc 1a, 2a, 3a, 4a, 5a, 6a	cc 1, 2	Using PS/STEP
Parasolid (PS/STEP)	cc 1a, 2a, 3a, 4a, 5a, 6a	cc 1, 2	Using PS/STEP
Bravo	cc 4a		No further development,
"Intergraph" EMS	cc 1*, 2, 4, 6	cc 1	Owned/Maintained by UGSolutions

Commercially available "STEP" translators are almost exclusively AP203 and the essentially "equivalent" AP214 cc1 & cc2 translators. In other words, geometry (wireframe, surfaces, and advanced B-Rep solids) and a subset of configuration management data are what have been implemented. There are some other commercially available STEP translators (AP202 - Pro/E, AP207 - CATIA, AP209 - MSC, AP210 - Mentorgraphics BoardStation (by ITI), and AP224 - Team SCRA/RAMP). The RAMP Program has its own process planning system (STEPPlan) which reads in AP224 and AP203 files, and several CAE vendors have indicated their intention to implement AP210. (An AP210 Implementation for Eagle (LKSoft) exists, and plans are underway for development of an AP210 translator for Zuken-Redac’s Freedom System (a 3-D ECAD System)). Others are still in the "planning" or negotiation stage with the vendors. The vendors need external funding or a business case to implement STEP AP's.

There are numerous prototype implementations of other STEP AP’s such as:

- SCRA’s Prototype AP210 Data Conversion and Verification Environment (DCVE) and AP220-based Generative Assembly Process Planner (GAPP) also exist. (See 2.8.4 and Document 11 in Appendix A.)
- ESTEP Prototype AP216 and AP218 implementations for selected conformance classes for several Shipbuilding Structural Design Systems (namely):
  - ISDP/GSCAD (Intergraph),
  - CATIA (Dassault Systems) (translators by STEP Tools, Inc),

- FORAN (Sener, Ingenieria Sistemes, S.A.),
- Tribon (Kockums Computer Systems) (translators by Atlantec Enterprise Solutions).
- Safe Hull (for Structural/Evaluation) (ABS)

♦ ESTEP Prototype AP227 (Edition 2) implementations for conformance classes 2,3,4 & 9 for Shipbuilding Piping and HVAC applications are underway at:
  - ISDP/GSCAD (Intergraph),
  - CATIA (Dassault Systems) (translators by Atlantec Enterprise Solutions),
  - FORAN (Sener, Ingenieria Sistemes, S.A.),
  - Tribon (Kockums Computer Systems) (translators by Atlantec Enterprise Solutions).
  - Simsmart (XML Part 28 implementation) (Modeling, Simulation & Analysis)
  - Microstation (Bentley), and
  - Electric Boat.(for EXPRESS/XML translation using STEP Tools, Inc. translators)

Several major aerospace companies are doing their own implementations as prototypes, proofs of concept and even production implementations in anticipation of requiring the capability for providing and/or receiving STEP formatted data from members of their supply chains.

This is especially true in the PDM and Technical Data Packaging areas (viz., the PDM Schema and AP232) where Boeing will be requiring the exchange of data with their suppliers in AP232 cc 4 & 6 format and Lockheed Martin requiring compliance with AP232 cc 1, 2 & 3. BAe Systems has already implemented the PDM Schema in Production, and Northrop Grumman has developed a prototype AP232/Metaphase interface for selected conformance classes of AP232.

Other examples of this type of STEP implementation:

As a part of the PDES, Inc. Engineering Analysis Pilot, several implementations of AP209 have been developed:

- Electric Boat implemented AP209 “In” for its “In-House” COMMAND System
- McNeal Schwendler (MSC) Software implemented AP209 “In” for Patran V9
- Theorem Solutions implemented AP209 “Out” for Catia V4

NASA-GSFC’s Next Generation Revolutionary Analysis and Design Environment’s (NextGRADE) Graphical User Interface (GUI) allows for AP209 import.

As a part of the STEP-NC/Super Model Project, prototype implementations of “AP238” have been developed by GibbsCAM, MasterCAM, and STEP Tools Inc. (ST-Plan).

4.2 Direct Translators, Services, and Tools

4.2.1 Direct Translators

It should be noted that a number of vendors and 3rd Party software development companies have developed direct translators for those CAD systems used frequently to exchange data. Below are some examples with references to related web sites. (This list has grown since the first publication of this Handbook.)

- **Cimsoftek –** supports many data formats used in MCAD – http://www.cimsoftek.com
- **Compunix -** Numerous combinations involving CATIA, UG, and Pro/E - http://www.compunix-usa.com/products/products.htm
- **Elysium, Inc. –** Direct translators between CAD systems including CATIA, I-DEAS, Pro/ENGINEER, Unigraphics, and SolidWorks. – http://elysiuminc.com/main_su.html
- **Geometric Software Solutions, Co Ltd. -** (Collaboration with Spatial/Dassault) – Feature Recognition and Data Exchange for CAD/CAM/CAE/PDM Systems – http://www.geometricsoftware.com
- **PlanetCAD (Intravision) –** Viewing and Conversion Software Products – http://www.planetcad.com/PROD/entsoliv.html
- **PTC -** direct geometry translators for CATIA®, PDGS, CADAM®,- http://www.ptc.com/products/proe/foundation/interfaces.htm
- **Spatial** (a Dassault Systèmes S.A company) **–** CATIA v4, Pro/E, Parasolid, ACIS - http://www.spatial.com/products/interop/Components/interop_spec/?LV3=Y
- **Theorem Solutions -** Combinations of CADDS, CATIA, SolidEdge, SolidWorks, Unigraphics, Mechanical Desktop, Pro/Engineer, etc. http://www.theorem.co.uk/docs/prodov.htm
  (To review: Select the CAD system listed in CADverter)
- **Translation Technologies, Inc. –** On-line service for conversion and exchange of CAD data, including web-based solutions – http://www.translationtech.com
- **UGSolutions -** CATIA/UG. PDGS/UG, CADD4X/5->UG http://support.ugs.com/services/data_exchange.html

4.2.2 Translation Services:

To meet the needs for product data exchange (usually for small and medium sized enterprises (SME's)), translation services have been established by some of the major players in the STEP community. More information on these translation services can be obtained by visiting the indicated web sites. (This list also has grown since the first publication of this Handbook. Many of these companies offer on-line and web-based on demand services.)

- **Cimsoftek –** supports many data formats used in MCAD (Pay per use or purchase)– http://www.cimsoftek.com

- **Geometric Software Solutions, Co Ltd -** (Collaboration with Spatial/Dassault) – Feature Recognition and Data Exchange for CAD/CAM/CAE/PDM Systems – http://www.geometricsoftware.com
- **ITI Data Exchange (DEX) Center (**http://www.iti-oh.com/pdi/dexcenter/index.htm**)**
- **DELCAM (PS-Exchange) –** Both Direct and Standards-based translation. Free PS-Exchange software download with a "Pay-Per-Use" scheme. (http://www.delcam.com/exchange/ps-exchange.htm)
- **STEP Tools, Inc. Translation Service (**http://www.steptools.com/strepo/translate.cgi**)**
- **Theorem Solutions -** Data Exchange Translation Services using both direct and STEP-based (AP203 or AP214) translators **(**http://www.theorem.co.uk/docs/bureau.htm**)**
- **UGSolutions -** Data Exchange Translation Services using both direct and standards-based (STEP AP203/214, flavored IGES, and DXF) translators **(**http://support.ugs.com/services/data_exchange.html **)**
- **PlanetCAD** (formerly a division of Spatial Technology Inc.) - Data Exchange Translation Services using Theorem Solutions' CADverter http://www.planetcad.com/PROD/entsolcadvert.html
- **PDES, Inc. Prove-Out System (for Members only) -** "Tests"/Proves-out commercially available STEP (AP203 and AP214) translators for models in numerous CAD Systems. (Currently, there are 7 CAD Systems in the PDES, Inc. Prove-Out Lab.)
- **Translation Technologies, Inc. –** On-line service for conversion and exchange of CAD data, including web-based solutions – http://www.translationtech.com

4.2.3 Solid Modelers

(See Vendor Web Sites for more detail on Products.)

- **Spatial Technology, Inc.** (Now part of Dassault Systemes) **-** ACIS - used as the solids modeling kernel in numerous CAD/CAM systems including AutoCAD, Mechanical Desktop, Design Studio, and others.
- **UGSolutions -** Parasolid - used as the solids modeling kernel in numerous CAD/CAM systems including Unigraphics, Solid Edge, SolidWorks, and others. http://www.plmsolutions-eds.com/products/parasolid
- **Dassault -** CATIA uses own proprietary solids modeling kernel.
- **PTC -** Pro/ENGINEER uses own proprietary solids modeling kernel.
- **SDRC -** I-DEAS uses own proprietary solids modeling kernel. (Expect this to become Parasolid with the EDS acquisition of SDRC.)

Comment: In theory, if a user is using a CAD System with an ACIS or a Parasolid kernel, that user can generate or read .sat (ACIS) or .xmt, x_t, or eXT (Parasolid) files. The user can then use an ACIS/STEP or a Parasolid/STEP translator, as appropriate, to generate or read a STEP AP203 (or AP214) file. This, theoretically, addresses STEP AP203/AP214 Advanced B-Rep translation for ACIS and Parasolid based systems.

4.2.4 STEP Tool Vendors

In the development of both the STEP Standard and STEP translators, some companies have developed tools to facilitate the development. Most notably in the STEP community are the following:

- **EPM -** EXPRESS Data Manager Suite of tools for application development and integration (Contains EDMmodelConverter which "uses EXPRESS-X to convert data from one EXPRESS schema to another") **(**http://www.epmtech.jotne.com/products/index.html**)**
- **ITI - (PDE/Lib, IGES/Works, CAD/IQ, CADfix)** (Changed name from ITI PDI to TranscenData (Global Interoperability Solutions)) http://www.transcendata.com
- **"NIST"**
  - ⇒ **EXPRESS Engine (**Formerly **EXPRESSO** (EXPRESS Language Environment) ("Freeware") (http://exp-engine.sourceforge.net/)
  - ⇒ **FEDEX** (EXPRESS Compiler) ("Freeware") **(**http://pitch.nist.gov/cgi-bin/sauder/express-server/server.cgi)
- **PDTec -** ECCO Toolkit (EXPRESS Compiler) ("provides the building blocks … and a software development environment to … implement product data technology" - (http://www.pdtec.de/)
- **STEP Tools, Inc. -** ST-Developer (to build and maintain STEP Applications) - (http://www.steptools.com/products/)

Also to be noted in the category of "tools" to help users are the "trouble shooting" tools such as CAD/IQ from TranscenData (formerly ITI PDI), and the geometry "healers" built into translators from Theorem Solutions, Dassault/Spatial, Unigraphics, Pro/ENGINEER, and others.

5. Some Pilots & Prototypes

At this point in time, robust commercial STEP translators include AP203 (cc's 1a, 2a, 4a, and 6a) and AP214 (cc's 1 & 2). These translators have been proved-out through rather extensive testing in forums such as PDES, Inc.'s STEPnet, ProSTEP's rally, and now the joint PDES, Inc./ProSTEP CAx-Implementors Forum. The early problems with accuracy and interoperability have essentially been eliminated, and the translators are of good quality.

Commercial implementation of other STEP AP's, with only a few exceptions as noted above, is rather slow in coming. But, this is not to say that other STEP AP's are not being tested. In fact there are, and have been, numerous pilots, prototypes and prove-outs throughout the world that are showing that STEP AP's in a wide variety of application domains can and do meet the requirements specified in the scopes of these application protocols.

These activities and the successes that they are demonstrating show that there is significant support throughout the world, especially in the CAD/CAM user community, for STEP to succeed. Most of the countries participating in TC184/SC4 have established STEP Centers. There are many STEP related R & D projects funded by national governments throughout the world. The CAD/CAM/CAE vendors participate in these prototyping projects to the extent to which they are funded. There is still limited vendor commitment to producing commercial STEP translation products at this point in time.

To illustrate the extent of the STEP related piloting activities, some of these many activities will be cited below with references given to web sites for additional information.

The SCRA's Advanced Technology Institute (ATI) houses PDES, Inc. which is an industrial consortium chartered with accelerating the development and implementation of STEP. More than twenty major automotive, aerospace and CAD/CAM vendor and user companies actively participate in their numerous STEP projects.
(visit http://pdesinc.aticorp.org/deploy.html)

PDES, Inc. Pilots:

- **STIR - STEP TDP Interoperability Readiness Pilot (AP232 & AP203 cc1)**
- **STEPwise - STEP web integrated supplier exchange (AP232/PDM)**
  - ⇒ An extension of the STIR Pilot
  - ⇒ Estimated Annual Pre-Production Savings per supplier - $64K
- **Eurofighter PDM Pilot (Unified PDM Schema)**
- **ISAP - International STEP Automotive Project**
  - ⇒ Joint with ProSTEP
  - ⇒ AP Interoperability (AP202, AP203, AP214)
  - ⇒ PDM
- **Electromechanical Pilot - AP210/AP203**
- **AEA - Aerospace Engine Alliance - AP203/PDM Schema**
- **Engineering Analysis - AP209**
- **TURBINE - AP203**
  - ⇒ Cross Section & Assembly Solid Models

- **AWS - Advanced Weapon System (AP203/AP202)**
- **CSTAR - (AP203 cc1) (**See Production Implementation @ McDonnell Douglas**)**
- **AeroSTEP - (AP203 cc5 & cc6) for Digital Pre-Assembly Solid (**See Production Implementation @ Boeing**)**
- **STAMP** – Supply-chain Technologies for Affordable Missile Products – AP232/STEP PDM Schema
- **VAST** – Validating Advanced Supply Chain Technology

ATI - NIST

- **PreAMP- Precompetitive Advanced Manufacturing Program - AP210CD/AP220WD**

ATI - DARPA

- **TIGER - Team InteGrated - Electronic Response - An extension of PreAMP (AP210 DIS & AP220 WD)**
- **STAMP - Supply-chain Technologies for Affordable Missile Products - AP232/STEP PDM Schema**

DARPA

- **MARITECH STEP Program -** Accelerate STEP development and assess implementability in U.S. Marine Industry

AIAG

- **AutoSTEP - AP203 cc6**
  - ⇒ Publications (http://www.aiag.org/)
  - ⇒ STEP/IGES Comparison
  - ⇒ Direct Translator Comparison

ATI - USAF/WPAFB-WL

- **PAS-C - PDES Application protocol Suite for Composites - AP203/AP209/AP232/AP222**

ATI - TACOM

- **TACOM Pilot -** an extension of PAS-C with the Army - AP203/AP209/AP232/AP222

NIST

- **Plant STEP Consortium - AP225**
- **STEP AP213 Coverage Analysis Pilot**
- **ATP – Supermodel/STEP-NC Project** (AP238 & ISO 14649)
- **IMS – Integrated Manufacturing Systems** (A series of Projects related to Manufacturing) http://www.ims.org

NSRP – ISEC

- ⇒ **ESTEP – AP216 & AP218 Prototype Demonstrations**
- ⇒ **Harvest – AP's 215, 216, 218 (to IS)**

Team SCRA/RAMP - DLA

- **STEP Feature-based Manufacturing Pilots**
- **Reports with Cost/Time Savings Metrics** (http://isg.scra.org/teams/step)
  - ⇒ **RAMP/STEP Site Prove-outs Phases 1 & 2 - AP224/AP203**
  - ⇒ **RAMP/STEP Commercial Pilot @ Texas Instruments - AP224/AP203**
  - ⇒ **RAMP @ Focus:HOPE - AP224/AP203**
  - ⇒ **STEP for Small/Medium Manufacturers Pilot - AP203**

Team SCRA – NAVSEA

- ⇒ **STEP Shipbuilding AP Development – AP's 215, 216, 218 (to DIS)**

Team SCRA – TACOM

- ⇒ **N-STEP – National automotive council STEP Enabled Production of components – STEP Manufacturing Suite** (See Appendix A Document 18)

Siemens NG (Germany)

- **Siemens Information Technology for Industrial Plants - AP212** (http://www.atd.siemens.de/itps/step/eng/scc_01.htm)

European Projects (Many of these projects are funded by ESPRIT.)

- **European STEP Centres Network (ESCN) - (**http://www.uninova.pt/~escn/prodlinks.html**) (Many of the following projects are cited at the above web site.)**
- **EPISTLE : European Process Industries STEP Technical Liaison Executive - Data Model used by for AP221, AP227, AP231**
- **PIPPIN : Pilot Implementation of Process Plant Lifecycle Data Exchange Conforming To STEP - AP221**
- **PROCESSBASE : ... contributions to STEP AP221**
- **SEASPRITE : Software architectures for ship product data integration and exchange.** Electronic data exchange in the shipbuilding industry using STEP AP216 & AP218.
- **FunSTEP :** Furniture STEP Development of a data model based on STEP for the manufacturers - customers integration in furniture industries.
- **CIMSTEEL : Computer Integrated Manufacture for constructional STEELwork - AP230**
- **PISTEP - Process Industries STEP - AP221 & AP227**
- **PdXi - product data eXchange institute - has lead development of AP231**
- **Petrotechnical Open Software Corporation & Caesar Systems, Ltd (POSC/Caesar) -** project to develop "STEP-like" standards for the Oil and Petrochemical Industries
- **SEDRES –** System Engineering Representation and Exchange Standardization (AP233)
- **STEP-NC** (ESPRIT) (AP238 & ISO 14649) http://www.step-nc.org

Japanese Projects (involving STEP) for the Process Industries

- **Power Plant STEP Working Group**
- **Plant CALS/STEP**

6. Some Production Implementations of STEP

Production STEP Implementations resulting from PDES, Inc. Pilot Projects:
(http://pdesinc.aticorp.org/deploy.html) --- See Press Release Archives for more detail and projected cost/time savings.

- **CSTAR - C-17 STEP Transfer And Retrieval** - Went production in 1995 at McDonnell Douglas (now Boeing) using AP203 cc1
- **AEROSTEP/PowerSTEP** (Boeing) - Went production in 1995 with Rolls Royce (Catia/CADDS5 - AP203 cc6) - Went production in 1996 with General Electric and Pratt & Whitney (Catia/UG - AP203 cc6) - In 1997 entered into agreement with Rolls Royce, General Electric, and Pratt & Whitney to exchange data using STEP AP203 to support digital pre-assembly verification for the 777 and 767-400 aircrafts.
- **General Motors STEP Translation Center** - Went production in 1996 to test and validate surface and solid model data exchange. Extensive STEP/IGES comparison analysis. CATI/UG translation services with GM Powertrain, Delphi/Delco Electronics, and Delphi Automotive divisions.
- **Lockheed Martin - Tactical Aircraft Systems** - Went production in 1998 with the use of CATIA STEP AP203 translators for data exchange on the F-16, JSF, F-22, KTX-2, and F-2 aircraft Programs. In 1999, Lockheed Martin-Tactical Aircraft Systems (LM-TAS), undertook the Virtual Product Development Initiative for Finite Element Analysis (VPDI-FEA) using AP209 DIS.
- **NASA** - Statement of policy that STEP Translators are required to be available at all NASA Sites
- **EuroFighter** – The members of the EuroFighter Aerospace Consortium (Alenia Aerospazio, BAe Systems, EADS-Germany, and EADS-CASA) have developed translators to convert internal data definitions to conform with the agreed upon STEP PDM Schema. The PDM systems for which the translators were developed included Metaphase, Enovia, and Optegra. The companies put these translators into production during 2001 for the EuroFighter Typhoon aircraft.
- **Team SCRA's RAMP Program has had STEP-Driven Manufacturing in production at Anniston Army Depot since 1994.** - The program developed Pro/ENGINEER STEP translator (STEPTrans) translates feature-based solid models into AP224 and AP203. The program developed process planning system (STEPPlan) uses the STEP files to develop process plans to drive the factory. STEPTrans, STEPPlan, and STEPValidator have evolved with the AP224 standard in this production environment over the years. These same STEP-based tools are used operationally in Team SCRA's On Demand Manufacturing (ODM) Vendor Network, comprised of over 50 companies. (See http://ramp.scra.org/ for greater detail).
- **TACOM N-STEP**
  The TACOM N-STEP program began in the Fourth Quarter of 2001 as a multi-year defense sponsored activity. The N-STEP objectives include an early production release in early 2002 of the SCRA STEP Manufacturing Toolset (STEPTrans, STEPValidator and STEPPlan) compliant with the 2nd Edition of AP224. Continuing through 2006 will result in a practical implementation of the STEP Manufacturing Suite (SMS) (See 2.9.1) as it evolves over time to include AP213, AP 232 and AP238 implementations. The N-STEP objectives are:

a. To successfully demonstrate that a STEP-enabled design, production, and lifecycle support environment for TACOM's weapons systems is operationally feasible, culturally acceptable, and readily executable;
b. To successfully demonstrate that the use of STEP-formatted product data, in conjunction with the employment of effective PDM and Configuration Management (CM) capabilities, offers measurable reduction in component production times and costs over the use of current forms of data; and
c. To successfully demonstrate the responsiveness and cost-effectiveness of a multi-organizational, Web-based network of suppliers for delivering both production and spare/replacement components and assemblies in support of TACOM-developed combat and combat support systems.

N-STEP has a strong R&D component as well as an emphasis on fabricating production parts for TACOM's weapon systems, both activities are STEP-centric and evolutionary. The initial focus will be on incorporating STEP-enabled production of machined parts in support of one or two of TACOM's mainstream programs, such as the Abrams tank, the Interim Armored Vehicle (IAV), and for the M113 personnel carrier. [Note: The term "machined parts" as used herein includes prismatic and turned parts normally fabricated in a machine shop, plus selective cast parts that require machining or can be more effectively supplied as machined parts. The initial participants in N-STEP, under the direction of the NAC, include SCRA as the prime contractor and project lead, the Cleveland Advanced Manufacturing Partnership (CAMP) with the role of generating STEP product data and serving as the reverse engineering experts, Focus:HOPE as a STEP-enabled manufacturing facility for fabrication and delivery of parts, General Dynamics Land Systems (GDLS) as a STEP-enabled manufacturing facility, and Anniston Army Depot (ANAD) as a secondary STEP-enabled manufacturing facility for certain selected parts.

The next section addresses the current STEP AP implementation status and provides some guidance on using what is available and on avoiding possible pitfalls. Once again, it is noted that until the latter part of 1999, only 3 STEP Application Protocols had achieved published IS status (i.e., AP201 & AP203 in 1994 and AP202 in 1996). Three additional STEP AP's were published as International Standards late in 1999. Six additional AP's have now reached IS status in 2001. STEP, the International Standard, has finally arrived on the scene. An examination of the scopes and associated conformance classes of these 12 STEP AP's indicates significant coverage of several important application domains. The standards represent considerable added capability. However, this capability can only be realized when the STEP AP's are implemented and available to the Engineering/Manufacturing community.

7. Some Guidance on Using STEP

In theory, the scopes of the Application Protocols and the defined Conformance Classes indicate the coverage of the various application domains. Numerous pilots, prototype implementations, and prove-out activities have taken place (especially over the past few years) lead by consortia such as PDES, Inc. and ProSTEP and internationally funded projects in the Process Industries, Shipbuilding and Manufacturing.

In reality, STEP in general use still consists primarily of several conformance classes of AP203 (primarily cc6a, along with cc's 2a & 4a) and cc1 and cc2 of AP214 which is essentially AP203 with a different set of CM data. These are the AP/cc implementations that most of the CAD/CAM Vendors have chosen to implement. However, many vendors have enhanced their translators by adding modules for supplementary capabilities (colors, layers, validation properties, groups, …), and almost all have added (or improved) "healing" capabilities.

So, at this time (from a production user point of view), when "we" talk about STEP, we really mean AP203 (cc's 1a, 2a, 4a & 6a) and/or AP214 (cc's 1 & 2). However, we are now at a point in time when many of the other STEP AP's have become International Standards. Twelve (12) STEP AP's have now achieved IS status (6 of those were published in 2001).

In many ways, the vendor community is in a quandary --- what STEP AP's should they implement? More specifically, what conformance classes of what AP's should they implement? These decisions need to be "user"/customer driven! Implementing multiple STEP AP's (i.e., numerous conformance classes for numerous AP's) is a huge undertaking for the vendors and would require a significant investment of time and resources to accomplish. Vendors have been slow to implement other STEP Application Protocols. A strong business case has not been presented to them. The vendors appear to be unwilling to extend their STEP capabilities, unless they are funded by the users to do so, or until they have a strong business case to do so.

There are some "high profile" STEP parts for which a business case might be established from the vendor point of view. (e.g., the PDM Schema and AP232.) In other instances, the "Users" will have to establish their own business case and provide funding to develop translators for their own purposes by outsourcing the work to the vendors or a translator "house" or developing their own translators in-house. As examples, Boeing is developing STEP AP232 cc's 4 (Parts List) & 6 (Indentured Data List) translation capabilities for their own use.

Some companies have presented themselves as translator development companies and others as translation services companies. It may happen that the user community may be able to establish a business case for these companies to develop a more extensive set of STEP translators. Strong business cases will have to be established for them to undertake this effort of expanding the translation of STEP AP's. The user community will have to "step to the table" with money in their hands to make it happen. It is almost certain that many of the STEP AP's (regardless of achieving IS status) will never be implemented as commercially available translators by the vendors. Some of these STEP AP's will get implemented "internally" within companies and shared with their supply chains in cases where the company feels that the costs are justified by the anticipated return on investment (ROI). Some companies will outsource this work to translator development companies.

It is highly unlikely that AP201 (IS in 1994) (STEP's "equivalent" of IGES's draughting specification) will be implemented by many vendors. (There have been implementations by the Japanese and ComSTEP.) PTC has the only implementation of AP202 (IS in 1996), but other Vendors have indicated that they might implement AP214's Draughting conformance classes (cc's 3, 4, and/or 10) which have been harmonized with AP202, rather than AP202 itself. This will depend on user demand.

Two STEP AP's with high visibility and interest are the Core Automotive Design AP214 and the Technical Data Packaging ("PDM") AP232. Both of these AP's have achieved IS status, and both have been and are currently being proven out with prototype/pilot implementations. There are numerous PDM vendors participating in the PDES, Inc./ProSTEP PDM - Implementors' Forum (PDM-IF) that have early/partial implementations of AP232 using the consensus STEP PDM Schema. Some of these are being used in some PDES, Inc. and ProSTEP pilots such as the EuroFighter Program. (BAe Systems has put their in-house developed PDM Schema system into production.)

Most of the current translator development activities appear to be project funded (e.g., ESTEP for the Shipbuilding AP's) or in-house developed (e.g., Boeing and Lockheed Martin for AP232). The vendors have "ventured forth" by enhancing their AP203 translators by adding supplemental modules, but not much beyond that.

The Shipbuilding and Process Industry Suites represent a significant user community throughout the world. These activities have had strong interest and support. There is high expectation that the STEP AP's evolving out of these efforts will be applied in these respective industries. Some of the vendors are involved in these projects, and commercially available translators will probably be derived from some of these prototypes. Still to be determined is the extent to which the vendor community is willing to provide the STEP data exchange translators to cover the expanding application domains. Once again, an industry driven business case will have to be presented in order for the vendor community to develop commercial translators for selected conformance classes of these AP's.

In summary, from the user's perspective, the question of **when** to use **what** AP and **why** depends on the development status of the various AP's and their availability on the CAD system translators of interest. The only commercially available STEP translators address geometry and some configuration management data (Essentially AP203 cc's 1a, 2a, 4a, 6a). There is considerable "experimenting"/testing going on with prototype implementations of STEP AP's that have reached varying stages of completion in the development and standardization cycle. There is some experimentation going on in the CAx-IF with "STEP" Application Modules (e.g., colours and layers, validation properties, associative text,…) in combination with AP203. The Application Module (AM) Architecture is being worked hard with the anticipation that Vendors would be more willing to implement "small" "plug and play" modules that can leverage common elements of numerous AP's and be combined in different combinations to achieve functionality equivalent to Application Protocols. The granularity and the number of the application modules required to achieve this goal is still to be determined. A listing of initial AM's has been developed. Nine (9) of these AM's (including colours and layers) have achieved ISO Technical Specification status (See Section 2.4.). STEP AP's currently under development are being encouraged to use the Application Module approach. AP's 203 (Edition 2), AP221, and AP233/PAS 20542 are doing this.

User are encouraged to examine the scopes and associated conformance classes of the STEP Application Protocols that have reached IS status (and those under development) to determine which, if any, will meet their data exchange needs. Then, a review of the commercially available STEP translators and the conformance class(es) implemented will determine if a STEP solution is available.

The PDES, Inc. STEPnet and PDMnet and ProSTEP Round Table/Rally testing have done much to ferret out and resolve translation problems and to stabilize the commercial translators for AP203 and AP214 (cc's 1 & 2) and to reach consensus on the STEP PDM schema. Reliability and performance have improved greatly and led to some recommendations and hints.

(From the PDES, Inc. Public Web Site) (http://pdesinc.aticorp.org)

"The CAx Implementor Forum is a joint testing effort between PDES, Inc. and ProSTEP. The objective of the forum is to accelerate CAx translator development and ensure that user's requirements are satisfied. The CAx Implementor Forum is an approach to establish a common test activity in the CAD area by merging PDES, Inc.'s STEPnet and ProSTEP's CAD Round Table. The goals of the CAx Implementor Forum are to:

- Implement functionality for today's needs
- Identify functionality for tomorrow's needs
- Avoid roadblocks by establishing agreed upon approaches
- Increase user confidence by providing system and AP interoperability testing
- Ensure new functionality does not adversely impact existing implementations

The CAx Implementor Forum and PDM Implementor Forum are significantly improving STEP translator quality and decreasing translator time-to-market."

Poor model quality, not STEP itself, remains one of the major barriers to the production use of STEP. "Many STEP translation failures and errors occur due to user modeling practices and/or CAD System algorithm errors."

"**A Check List for Data Exchange** (From Theorem Solutions Web Site) (http://www.theorem.co.uk)

1. During the dialogue between receiver and sender the following points need to be covered:
2. Define the purpose of the transfer, e.g. design modification, machining.
3. Define number of models/drawings.

4. Define the volume of data to be converted.
5. Define scope of transfer, e.g. 2D/3D or both
6. Associativity to be maintained?
7. Define acceptance limits for the transfer.
8. Check Drawing Office practices.
9. Check the magnetic media to be used.
10. Check the operating system environments, i.e. UNIX, NT or other.
11. Agree which data compression utilities (if any) will be used.
12. Check CAD systems and versions.
13. Check versions of the converters to be used.
14. Is a process required to be established or is it a one-off transfer?
15. For each converter to be used check:
16. Which CAD entities are covered by the converter.
17. Check which entities will be created from each CAD entity translated.
18. What options does the converter have?
19. What version of data is created?

If a standards-based solution is used, requiring two processors, check:

1. Which entities are converted to CAD entities.
2. Check which CAD entities are created from each neutral file entity translated.
3. What options do the pre- and post-processors have?
4. What version of the neutral format can be read. "

"General Information and Techniques for Improving STEP Translation Success
(From the PDES, Inc. CAx-IF Website @ http://www.cax-if.org/bestprac/practice.html)

Modeling

- Use entity types that are supported by your translator or defined in exchange agreements
- Wherever possible use basic geometry and primitive solids to create the model
- Avoid modeling practices that can create geometry which cannot be exchanged, as in constructing solids where topological edges converge at a single degenerate point
- Use the highest precision when creating a part
- Most CAD vendors today implement AP 203 (configuration managed 3D design data), Conformance classes 2, 4, and 6
    - Class 6 is advanced boundary representation solids
    - Class 4 is topologically bounded surfaces
    - Class 2 is geometrically bounded wireframe and surfaces
- AP 214 implementations so far have mainly copied AP 203 geometry
- Use b-rep solids since facetted boundary representation solids corresponds with the little-implemented AP 203 class 5
- If you must use wireframe, make it geometrically bounded since topologically bounded wireframe corresponds with the virtually unimplemented AP 203 class 3

Importing STEP Files

- Confirm that files are defined to the agreed standard

- Verify that files have not undergone any conversions that may have corrupted them, e.g. ASCII to EBCDIC conversion can convert special characters, which have a meaning in STEP files
- Ensure that files have not been truncated, e.g. to 80 character records, or in length

Exporting STEP Files

- For assemblies, confirm that all component files are in the same directory
- Make all geometry visible and selectable
- Remove unnecessary geometry, layers, annotation from the file(s)
- Use tools available in the native system to validate geometry prior to export
- Ensure that the STEP translator can support the nature of the data to be exchanged"

Some User Guidelines/Hints/Analysis Websites:

- **PDES, Inc.** Best Practices Guidelines (PDES, Inc. - Public) --- http://www.cax-if.org/bestprac/practice.html
- **ProSTEP** Best Practices Guidelines (ProSTEP Public) --- http://www.prostep.org/de/stepportal/best-practices/ (in German)
- **UKCEB Hints**
  - ⇒ http://www.ukceb.org/step/pages/hints_data.htm
  - ⇒ http://www.ukceb.org/step/pages/hints_modelling.htm

8. Certification of STEP Translators

Some sort of "Official" Certification for STEP Translators has always been a goal of the ISO STEP community. The definition of certification has been an issue. Is it simply semantic and syntactic conformance to the AP's schema and STEP's syntax? The requirement for and the development of Abstract Test Suites (ATS) provide the basis for certifying a STEP translator for a specified conformance class of a specified AP.

Agreements have been reached within the ISO TC184/SC4 STEP community on what constitutes certification of a STEP translator and an agreed upon process for determining certification. A 1999 Memorandum of Understanding (MOU) signed by the four STEP Centers: PDES, Inc. (USA), GOSET (France), JSTEP Japan), and C-STEP (China) supporting STEP Certification. The U. S. Product Data Association (USPRO) has been designated as the administrator for the STEP Certification Program and the Center for Electronic Commerce (CEC) at the Environmental Research Institute of Michigan (ERIM) has been designated to conduct the certification testing and to validate the results.

The procedures are designed to be performed electronically with a mechanism for conducting sample self-testing prior to initiating the "real" certification test. Translators can be certified as preprocessors (generating STEP files) and/or as postprocessors (reading in the STEP file). Official STEP Certification testing was initiated in 1999 and to date, seven (7) Vendor translators have been bi-directionally certified for AP203 cc 6a where the "a" designates the "agreed upon" minimal subset of cc1 configuration management data. The certified translators are Dassault's CATIA 4.2.2, UGSolutions' UNIGRAPHICS v16, Autodesk's Mechanical Desktop 4.1, Theorem Solutions' CADDS5 v4.0, SolidWorks 2000, Alibre's Design, and MSC's Patran 2001 r1. Note: at this time, AP203 cc6a is still the only STEP AP and conformance class that the STEP Certification Bureau is certifying.

STEP Certification for translators will be based on ATS Test Cases for each AP and conformance class. As noted, the USPRO/ERIM-CEC Certification is currently only performing certification testing for AP203 cc 6a (i.e., Advanced B-Rep with minimum subset of CM (cc 1a)). Eventually, as more Abstract Test Suites and/or test cases become available and commercial translators for more STEP AP conformance classes are developed, more comprehensive certification coverage (in theory) will also become available.

STEP Translator Certification Information
(http://stepcert.erim.org and http://stepcert.erim.org/certfaq.html)

"This website can be used to conformance test STEP based software products. Successful completion of testing is required for official USPRO certification of the products. Follow the procedure to register for testing, completing the tests, and seeking USPRO certification.

Contact USPRO for information and application proformas. Upon completion of the application process with USPRO, you will receive a login account and password to enter this web site and use it for conformance testing. Your account will be private and accessible only to you and support staff in the CEC. If you have questions, you could contact USPRO or the CEC.

US PRO Trident Research Center, Suite 204
5300 International Boulevard
North Charleston, SC 29418
Fax: +1 803-760-3349
Email: stark@aticorp.org "

9. Summary

The development and implementation of STEP Standards is dynamic and on-going. This handbook represents a “snap shot” of the information as it exists at this point in time.

This handbook is a collection of information on the current state of STEP and it’s current usability. It's intent was to provide information of value to engineering users with a need to exchange product data with customers and/or suppliers.

The handbook concentrated on identifying the application domains being covered by STEP development, identifying commercially available tools for using STEP, providing guidance on using the STEP technology that is currently available, and providing sources of additional information.

The current status of STEP development was presented with emphasis on those parts of STEP that have achieved International Standard (IS) status and those parts/application domains that are currently being developed. The scopes of these STEP Application Protocols (AP's) were presented to indicate what is and isn't addressed in the AP's. This information was presented so that the engineering user was able to see the depth of coverage of the AP's and to identify those STEP AP's and their associated conformance classes that best will meet the user's product data exchange (PDE) requirements.

A table was provided showing commercially available PDE translators from the major CAD/CAM vendors. This table includes STEP translators as well as direct translators and translators that use other PDE formats.

At this time, commercial implementation of STEP still is mainly limited to several conformance classes of AP203 - Configuration Controlled Design and two conformance classes of AP214 - Core Data for Automotive Mechanical Design Processes which are roughly equivalent to AP203. Reference is made to those major companies who have put this current STEP capability into production.

Numerous pilot, prototype and proof-of-concept implementations of the many STEP Application Protocols were cited to emphasize the successful demonstration of the power and robustness of the evolving STEP standards.

An attempt was made to distinguish between what is “real” now and what is theoretically possible (& achievable) in the future and to identify some of the current obstacles to achieving the ultimate goal of STEP. (i.e., to provide a complete, unambiguous, neutral computer-interpretable standard for representing product data throughout the lifecycle of the product.)

Some guidance was provided for the engineering user in using the currently available STEP capability. Some hints, guidelines and checklists were provided and referenced to assist in using the currently available STEP technology.

The STEP that is commercially available to the engineering user community is essentially AP203 and its "look alike" AP214 cc 1&2 (i.e., geometry (wireframe, surfaces & solids) with some configuration management data). What is available is really very good --- good enough to be in production at Boeing, Lockheed Martin, General Motors, General Electric, Pratt & Whitney, Rolls Royce and other large companies. But STEP presents a much more powerful and robust technology that has been and is being demonstrated in numerous Research & Development environments.

STEP still is frequently misunderstood in the general engineering user community. It is still evolving, and STEP is now at a point in its evolution when a significant number of Application Protocols have achieved International Standard status. There are twelve (12) STEP AP's that have achieved IS status. STEP is and will be more than AP203. The user community has to start looking more closely at the AP's and their associated conformance classes (cc's) to determine what components/parts of STEP best meet their requirements. Users need to refer to STEP by AP and conformance class. In order to realize the "full" power of STEP, the user community has to drive the implementation of the AP conformance classes that they need to meet their business objectives. In order for this to happen, strong business cases are going to have to be developed. This might result in the users funding the development of these implementations. This might be funding the CAD/CAM/CAE Vendors to build translators. It might be outsourcing the implementation to a translator development company --- several of these have started up, in fact some vendors are now taking this route. It might be developing translators in-house --- some large companies have done this.

The handbook concentrated on identifying the application domains being covered by STEP development, identifying commercially available tools for using STEP, and providing guidance on using the STEP technology that is currently available. It addressed those STEP Application Protocols (AP's) that have achieved International Standard (IS) status and those that are currently being developed. It identified those AP's that are currently implemented and have commercially available translators, and those AP's that have been or are currently being piloted, prototyped, or proved-out.

APPENDICES

APPENDIX A - Documents

1. The Economic Benefits of Advanced Product Data (Draft), DL910T1, Michelle M. Kordell & Eric L. Gentsch, Logistics Management Institute, December 1999.

2. The Applicability of STEP to Automotive Design and Manufacturing, Automotive Industry Action Group (AIAG) D-10, March 10, 1998.

3. SCRA RAMP STEP-Driven Manufacturing Prove-Out Reports: (with metrics) (http://isg.scra.org/products/step_ap224.html)

   a) Final Report for STEP Driven Manufacturing at Small and Medium Manufacturers Pilot Project, DLA RAMP Program, Team SCRA, July 15, 1997.

   b) RAMP Site Proveout of STEP Filesets Project - Phase 1 (June 8, 1994 - February 24, 1995)(Final Report-General Release), TAR2017005-0, RAMP Program, Team SCRA, (Reproduced & Distributed by USPro), March, 1995.

   c) RAMP Site Proveout of STEP Filesets Project - Phase 2 (February 25, 1995 - July 17, 1996)(Final Report), TAB2017009-0, RAMP Program, Team SCRA, March 26, 1997.

   d) RAMP Technology Transfer Pilot Program (Final Report), Texas Instruments Defense Systems and Electronics, November 21, 1996.

   e) Rapid Acquisition of Manufactured Parts Pilot Project (Final Report), Team SCRA & Focus:HOPE, July 31, 1997.

4. Product Data Exchange Technologies Success Story Booklet, IGES/PDES Organization (IPO) Workshop, Gaithersburg, Maryland, January 27, 1997.

5. The Historical Need for STEP (A White Paper), Howard Mason (British Aerospace)

6. STEP Development Methods, (A White Paper), Julian Fowler (CADDETC-Fomerly), March 7, 1995.

7. STEP:Towards Open Systems-STEP Fundamentals and Business Benefits, Dr. Kais Al-Timimi & John MacKrell, CIMdata, September, 1996.

8. Introducing STEP - The Foundation for Product Data Exchange in the Aerospace and Defence Sectors, National Research Council Canada, C2-447/1999, Susan Gilles (ed), 1999.

9. STEP-The Grand Experience, NIST, Sharon J. Kemmerer (ed.), July 1999

10. STEP-The Future of Product Data Exchange (An AIAG Booklet), Dick Justice, Russell Doty & Mike Strub, 1995.

11. On-demand manufacturing of Printed circuit assemblies Using STEP (OPUS), W. B. Gruttke, W. B. Freeman, C. T. Lanning & K. D. Buchanan, EMI International, April 1999.

12. STEP-Driven Manufacturing, CASA/SME Blue Book Series, John H. Bradham, 1998.

13. Fundamentals of STEP Implementation, Dave Loffredo, STEP Tools, Inc., http://www.steptools.com/library/fundimpl.pdf

14. STEP Manufacturing Suite, (A White Paper), Team SCRA, 30 September 2001, http://isg.scra.org/teams/step.html

15. "AP213: Numerical Control (NC) Process Plans for Machined Parts" (A White Paper for ISO TC184/SC4), L. Slovensky, K. Yee, W. Simon, June 2000

16. "Integrating Product Data Standards", Len Slovensky, Plant Services, August 2000

17. "STEP into Automatic Machining", (STEP-NC White Paper), Martin Hardwick, STEP Tools, Inc., August 2001

18. STEP Application Handbook (First Edition), Team SCRA, 1 June 2000, http://isg.scra.org/teams/step.html

19. The Engineering Analysis Core Model – A 'plain man's guide'. David Leal, December 1999, http://pdesinc.aticorp.org/ (PDES Inc.'s Public Website – STEP Capabilities – Engineering Analysis)

APPENDIX B – Web Sites

1. Team SCRA - RAMP Product Data --- http://www.isg.scra.org/teams/step.html

******* STEP Centers *******

2. Australasian STEP Data Exchange Centre (AUSDEC) --- http://www.ausdec.com.au/
3. Portuguese STEP Center --- http://www.uninova.pt
4. Fujitsu STEP Research & Development Center --- http://www.fqs.co.jp./STEP/
5. Italian STEP Center (CeSTEP) (in Italian) --- http://www.uninfo.polito.it/CESTEP/stepmenu.htm
6. Japanese STEP Promotion Center (in Japanese) --- http://www.jstep.jipdec.or.jp/
7. PDES Inc. Public Website --- http://pdesinc.aticorp.org/
8. ProSTEP --- http://www.prostep.de/
9. STEP Akeda Laboratory (Japan) --- http://www.hike.te.chiba-u.ac.jp/ikeda/documentation/STEP.html
10. STEP in Finland ---
    http://cic.vtt.fi/links/step.html (Building & Construction)
    http://cic.vtt.fi/links/euproj.html (List of Projects)
11. Swedish STEP Centre (SwedSTEP) (in Swedish) --- http://www.psm.kth.se/swedstep/
12. UK Council for Electronic Business (UKCEB) Website --- http://www.ukceb.org/step/

******* Standards Organizations *******

13. ANSI --- http://www.ansi.org/
14. GOSET --- http://www.goset.asso.fr/
15. ISO --- http://www.iso.ch/iso/en/ISOOnline.frontpage
16. ISO Standards Query --- http://www.iso.ch/iso/en/Standards_Search.StandardsQueryForm
17. NIST --- http://www.nist.gov/welcome.html
18. NIST SC4 On-Line Information Service (SOLIS) --- http://www.nist.gov/sc4/
19. SC4 Project Management Database --- http://www.nist.gov/sc4/sc4dbase/
20. US Product Data Association (USPro) --- https://www.uspro.org/

******* Information, Overviews, Summaries *******

21. NIST SOAP Website (Updated 2001-11-28): --- http://www.nist.gov/sc5/soap/ --- STEP On A Page
22. PDES, Inc. STEP Part Descriptions --- http://pdesinc.aticorp.org/aps.html
23. PDES, Inc. STEP Overview --- http://pdesinc.aticorp.org/whystep.html
24. ProSTEP Best Practices (in German) --- http://www.prostep.org/de/stepportal/best_practices/
25. Theorem Solution White Papers --- http://www.theorem.co.uk/docs/standard.htm

******* Tools *******

26. EPM Technology Products --- http://www.epmtech.jotne.com/products/index.html
27. EuroSTEP --- http://www.eurostep.se
28. EXPRESS Engine (Formerly EXPRESSO) --- http://exp-engine.sourceforge.net
29. InterData Access (IDA) (Spatial Technology) --- http://www.spatial.com/products_services/interop/Components/ACIS_interop.htm
30. International TechneGroupe Inc. (ITI) --- http://www.iti-oh.com
31. PDTec Products --- http://www.pdtec.de/
32. STEP Tools, Inc. --- http://www.steptools.com/

******* Vendors *******
33. Alias Wavefront --- http://www.aliaswavefront.com/design/products/consumer_products/designstudio/pdf_brochure/index.pdf
34. Alibre --- http://www.alibre.com/solutions/
35. Autodesk Data Exchange Products --- http://www.autodesk.com/products/dataexch/index.htm
36. Autodesk - XchangeWorks --- http://www.xchangeworks.com/ (Free Plug In)
37. CATIA/CADAM Interface Products/ IBM Data Exchange Services --- http://www-3.ibm.com/solutions/plm/catialog.nsf/$defaultview?openview
38. PTC Pro/E Interfaces --- http://www.ptc.com/products/proe/foundation/interfaces.htm
39. SDRC (Now Part of EDS) --- http://www.plmsol-eds.com/home.shtml
40. Solid Edge Translators:
    --- http://www.solid-edge.com/voyager/theorem.htm
    --- http://www.solid-edge.com/voyager/cat_translators.htm
41. Solid Edge Website --- http://www.solid-edge.com/
42. TranscendData (formerly ITI PDI) --- http://www.transcendata.com/
43. UGSolutions Products ---
    --- http://www.plmsolutions-eds.com/products/unigraphics/solutions/index.shtml
    --- http://support.ugs.com/services/data_exchange.html
    --- http://www.plmsolutions-eds.com/products/bravo/pdm.shtml
    --- http://www.ugs.com/platform/interoperate.shtml
44. Theorem Solutions --- http://www.theorem.co.uk/ (CADverter)
******* Industry Group *******
45. AIAG --- http://www.aiag.org/
46. UK Process Industries --- http://www.marchland.com/pistep/index.htm
47. NIDDESC --- http://www.nsnet.com/NIDDESC/niddesc.html
48. ISO TC184/SC4/WG3/T23 --- http://www.nsnet.com/NIDDESC/t23.html
******* Other *******
49. IMTECH View Formats --- http://www.imtechdesign.com/3dview/index.htm

APPENDIX C – Scopes for ISO 14649 Parts

ISO 14649 – Data Model for Computerized Numerical Control (CNC)
(ISO 14649 Parts are being developed in ISO TC184/SC1)

- **ISO/DIS 14649-1 Overview and fundamental principles**
  Data model for computerized numerical controllers. Overview and fundamental principles.

- **ISO/DIS 14649-10 General process data**
  "This part of ISO 14649 specifies the process data which is generally needed for NC-programming within all machining technologies. These data elements describe the interface between a computerised numerical controller and the programming system (i.e. CAM system or shopfloor programming system). On the programming system, the programme for the numerical controller is created. This programme includes geometric and technological information. It can be described using this part of ISO 14649 together with the technology-specific parts (ISO 14649-11, etc.). This part of ISO 14649 provides the control structures for the sequence of programme execution, mainly the sequence of working steps and associated machine functions."

  The "machining_schema" defined in this part of ISO 14649 contains the definition of data types which are generally relevant for different technologies (e.g. milling, turning, grinding). The features for non-milling technologies like turning, Electrical Discharge Machining (EDM), etc. will be introduced when the technology specific parts like ISO 14649-12 for turning, ISO 14649- 13 for EDM, and ISO 14649-14 for contour cutting of wood and glass are published. It includes the definition of the workpiece, a feature catalogue containing features which might be referenced by several technologies, the general executables and the basis for an operation definition. Not included in this schema are geometric items and representations, which are referenced from ISO 10303's generic resources, and the technology-specific definitions, which are defined in separate parts of ISO 14649.
  This part of ISO 14649 cannot stand alone. An implementation needs in addition at least one technology-specific part (e.g. ISO 14649-11 for milling, ISO 14649-12 for turning).

  Additionally, the schema uses machining features similar to ISO 10303-224 and ISO 10303-214. The description of process data is done using the EXPRESS language as defined in ISO 10303 11. The encoding of the data is done using ISO 10303-21.

- **ISO/DIS 14649-11 - Process data for milling**
  The purpose of ISO 14649 - 11 is to:
  - Re-establish an accepted standard for the transmission of NC data to the shop floor!
  - Provide motion control data based on splines for sophisticated, high-speed NC cutting operations
  - Avoid intermediate data formats (CLDATA)
  - Provide all necessary data for easy modification of NC data at the machine controller
  - Replaces the old "M and G" codes with "working steps"

This part of ISO 14649 specifies the technology-specific data elements needed as process data for milling.

Together with the general process data described in ISO 14649-10, it describes the interface between a computerized numerical controller and the programming system (i.e. CAM system or shopfloor programming system) for milling . It can be used for milling operations on all types of machines, be it milling machines, machining centers, or lathes with motorized tools capable of milling. The scope of this part does not include any other technologies, like turning, grinding, or EDM. These technologies will be described in further parts of ISO 14649.

Subject of the milling_schema, which is described in this part of ISO 14649, is the definition of technology-specific data types representing the machining process for milling and drilling. This includes both milling of freeform surfaces as well as milling of prismatic workpieces (also known as 2½D-milling). Not included in this schema are geometric items, representations, manufacturing features, executable objects, and base classes which are common for all technologies. They are referenced from ISO 10303's generic resources and ISO 14649-10. The description of process data is done using the EXPRESS language as defined in ISO 10303-11. The encoding of the data is done using ISO 10303-21.

OUT OF SCOPE:

- turning
- grinding
- EDM

The scope of this part of ISO 14649 does not include tools for any other technologies, like turning, grinding, or EDM. Tools for these technologies will be described in further parts of ISO 14649.

- **ISO/NWI 14649-12 Process data for turning**
  (The scope of this part will be analogous to Part 11, except that it will address turned parts.)

- **ISO/DIS 14649-111 Tools for milling**
  This part of ISO 14649 specifies the data elements needed as tools for milling. They work together with ISO 14649- 11, the process data for milling. These data elements can be used as a criteria to select one of several milling and drilling type tools, not to describe a complete information of a particular tool. Therefore, leaving out optional attributes gives the controller more freedom to select from a larger set of tools. The NC is assumed to have access to complete description of specific tools in a database.

  The milling_tool_schema defined in this part of ISO 14649 serves as a basic tool schema including just the most important information. It is intended to give the controller enough information to select the tool specified in the NC program.

  In ISO 6983, the tool is defined just with its number (e.g. T8). No further information concerning the tool type or geometry is given. This information is part of the tool set-up sheet, which is supplied with the NC-program to the machine. The tool set-up sheet gives the relationship between the tool location (e.g. slot 8) and the type of tool (e.g. "drill 4 mm").

The approach of this tool sheet to ISO 14649-11 is to include the information which is contained in the tool set-up sheet mentioned above in the NC program. Therefore, the most important information which needs to be included in the tool description is:

- tool type
- tool geometry
- expected tool life

The tool schema does not include information which is part of the tool database. The tool database is related to the machine and the tools themselves but independent of the NC program. This means that data like the following data types are not included in the tool schema:

- normative tool life
- tool location in the tool changer

The tool schema does not include information about tool holders and tool assembly components.
It is important to understand that all length measure types used in this Part are not toleranced length measure types because they are used to describe the tools **required** for the manufacturing of a workpiece, not the actual dimensions of the tools available at the machine. A real tool must be selected by the tool management based on the actual tool dimensions and the tolerances of features.

The overall structure of the tool description in this part of ISO 14649 and ISO 14649-10 is the same with ISO/DIS 13399-1. Many definitions of tool body and it's geometry are referenced from the NIST tool model. [NISTIR5707:Modeling of Manufacturing Resource Information, July,1995]

OUT OF SCOPE
The scope of this part of ISO 14649 does not include tools for any other technologies, like turning, grinding, or EDM. Tools for these technologies will be described in further parts of ISO 14649.

- **ISO/NWI 14649-112 Tools for turning**

(The scope of this part will be analogous to Part 111, except that it will address turned parts.)

APPENDIX D – Scopes for ISO 13584 Parts

ISO 13584 Industrial automation systems and integration -- Parts library
(ISO 13584 Parts also are being developed in ISO TC184/SC4)

- **ISO 13584-1:2001 Overview and fundamental principles**

This part of ISO 13584 defines the basic principles of parts library data representation and exchange used in this International Standard. It specifies the characteristics of the various series of parts in ISO 13584 and the relationships between them.

The following are within the scope of this part of ISO 13584:

- an overview of this International Standard;
- the structure of this International Standard;
- an overview of methods used in this International Standard;
- an overview of the relationship of this International Standard with ISO 10303, Product Data Representation and Exchange.

- **ISO 13584-20:1998 Logical model of expressions**

This part of ISO 13584 specifies:

- The EXPRESS schema for generic expressions;
- The EXPRESS schema for expressions, that models the subset of the allowed expressions in the EXPRESS language defined in ISO 10303-11 that corresponds to integer, real, boolean and string datatypes. This schema subtypes the generic expression schema.

The following are **within** the scope of this part of ISO 13584:

- The exchange of expressions that involve both constants and variables;
- The computation of the type of the value modelled by an expression;
- Checks to ensure that an expression is semantically correct;
- Checks to determine if an expression may be mapped on to the SQL query language.

The following are **outside** the scope of this part of ISO 13584:

- The interpretation function that assigns values to variables within some context;
- The triggering mechanism that computes the value of an expression in a given context.

- **ISO/DIS 13584-24 Logical model of supplier library**

This part of ISO 13584 provides the generic resources for supplier library modelling and exchange. It also provides the EXPRESS integrated information models that permits the exchange of level 1 and level 2 libraries that contains only part definitions and/or supplier-defined representations, whether these library descriptions consist only of dictionary definitions or whether they contain also the specification of the allowed instances. This part of ISO 13584 finally specifies the implicit integration process that permits the exchange of level 1 and level 2 libraries that contain reference to any part of the view exchange protocol series of parts of ISO 13584.

The following are **within** the scope of this part of ISO 13584:

- The generic resource constructs for modelling the description of hierarchies of components families and of assembled parts families, whether they consist of abstract parts (e.g., parts families defined by product Standard) or supplier parts;
- The generic resource construct for modelling the content of components families and of assembled parts families;

- The generic resource construct for modelling representations of these parts, both in a library and in product model data;
- The integrated information model that permit the exchange of level 1 and level 2 libraries that contains only part definition and/or supplier-defined representation;
- The integration process between the resources defined in this part of ISO 13584 and the resources defined in the view exchange protocol series of parts of ISO 13584.

The following is **outside** the scope of this part of ISO 13584:

- The description of assembled parts that require a list-structured description of the parts they consist of;
- The implementation resources required on the user system to connect its library with some product modelling system;
- The implementation methods used for exchanging libraries.

NOTE: All the implementation methods specified in ISO 10303 for exchanging population conforming to EXPRESS-based information models are allowed implementation methods for the exchange of ISO 13584 conforming libraries.

The scheme contained in this document are as follows:

- The ISO_13584_dictionary_schema contains the extensions of the ISO IEC dictionary schema required for parts library modelling and exchanging. Its Library entity is the root that permits compiling of a complete library: only the entities referenced directly or indirectly (through direct or inverse attributes) by a library entity are intended to be compiled.
- The library_content_schema describes the content of the classes that constitutes the library.
- The instance_schema defines the information models of instances of classes and properties defined in a libraries. Such instances are, in particular, used in tables and in derivation functions.
- The instance_operation_schema provides the resources for expressing operation on class instances. Operations consist of functions, constraints and methods.
- The table_schema provides the resources for modelling tables. Such tables are used both to describe a class extension and to define derivation functions.
- The external_file_schema provides the resources for referencing external files whose content is not necessarily defined by an EXPRESS information model. It provides for referencing programs, explicit representations (e.g., ISO 10303 representations), and any other files whose contents may be specified by other Standards.
- The method_schema provides the resources for modelling methods able to create functional views in a user modelling system.
- The level_1_library_content_schema is the integrated information model of a Level 1 supplier library. In this schema, properties are not allowed to be optional, property values are restricted to simple types, and expressions are restricted to those that may be mapped onto the SQL language. This clause also specifies the implicit integration process of the schemes defined in this part of ISO 13584 and those defined in the view exchange protocol series of parts of ISO 13584.
- The level_2_library_content_schema is the information model of a Level 2 supplier library, i.e., libraries that contain assembled parts.

For the exchange of functional model classes that describe representation of parts conforming to some view exchange protocol, the two last scheme are intended to be implicitly integrated with the schema, or scheme, defined in the view exchange protocol series of parts of ISO 13584.
(NOTE: In the present version of this document some WHERE rules may remain non formally stated. Nevertheless, the are precisely stated in the formal propositions clause and all the functions that enables their formal expression are available.)

- **ISO/DIS 13584-25 Logical model of supplier library with aggregate values and explicit content**

This part of ISO 13584 provides generic EXPRESS resource constructs that support the description of aggregate data types and values occurring in supplier libraries. It also contains an integrated EXPRESS information model for representing supplier libraries for the purpose of exchange. This integrated information model integrates the above resource constructs with other EXPRESS resource constructs from different parts of ISO 13584 and ISO 10303 into one single schema. Supplier libraries may consist of definitions and of representations of families of parts. They may also define new representation categories. Supplier libraries may consist only of dictionary elements with or without aggregate data types, or they may also contain explicit specifications of the sets of permitted instances.

When used together with view exchange protocols, this integrated information model also permits the exchange of one or several representation categories for the parts defined in a parts library.

The following are within the scope of this part of ISO 13584:
— generic resource constructs for representing aggregate data types. Aggregate data types and values are modeled according to the definition of aggregate data types of the EXPRESS language (ISO 10303-11: 1994);
— generic resource constructs for representing aggregate values;
— description of assembled parts that may contain an unlimited number of constituent components;
— a library integrated information model that provides for modeling and exchanging supplier libraries that contain properties whose values may be aggregate-structured, and whose possible class extensions are explicitly described as sets of instances.

- **ISO 13584-26:2000 Information supplier identification**

This part of ISO 13584 specifies a supplier code to identify the suppliers of a library.
The supplier code shall enable the user of a library to trace the supplier of any part that has an entry in the library and to trace the data given by a particular supplier.

- **ISO 13584-31:1999 Geometric programming interface**

This part of ISO 13584 specifies an application programming interface that enables an application program to generate geometric models which are independent of the target user system. The interface allows portability of programs which describe parametric shape representations of parts families held in a ISO 13584 parts library.
The following are **within** the scope of this International Standard:

- programs to generate geometric representations within a modelling system which are independent of the target system.

- programs which specify geometric representations that are created through constraint-based geometric definitions.
- programs which structure geometric representations created independently of the target system.
- programs which specify presentation style attributes for symbolic visualization of representations created.
- programs which support technical drawing standard conventions for shape representation, including a 2D hidden line mechanism.

The following are **outside** the scope of this International Standard:

- -The precise control of the image to be displayed on the receiving system devices,
- -The precise definition of the data that shall be created on the receiving system,
- -The storage of a parametric model on the receiving system.

- **ISO 13584-42:1998 Methodology for structuring part families**

This part of ISO 13584 specifies: rules to group parts into generic families of parts and simple families of parts, as described by the Conceptual Model which constitutes the part 10 of this International Standard;

- rules to choose the appropriate properties which shall be associated with the families of parts;
- descriptors that shall be provided by library suppliers to describe the families and properties of parts. These descriptors are part of the content of their parts library and shall be stored in the semantic dictionary of the user library.
- specifications of these descriptors in the EXPRESS information model that provides for the exchange of such dictionary data.

NOTES:

1. The EXPRESS information model that provides for the exchange of dictionary data is defined in IEC CD 1360-2.
2. The content of this EXPRESS information model is provided, for informative purpose, in the informative Annex A of this part of ISO 13584. Thus, the task is to:
    - define the reference hierarchy or the supplier hierarchies of parts and the properties associated with these parts.
    - exchange the implicit description of the different parts that constitute families of parts (as specified in ISO 13584-10 and ISO 13584-24).

The rules are primarily intended for standardization committees responsible for creating standardized reference hierarchies. The aim of a reference hierarchy is to make multi-supplier access possible, by providing pre-existing dictionary entries that may be referenced by library suppliers. The use of these rules by suppliers and users is recommended as a methodology for building their own hierarchy.

The following is **outside** the scope of this part of ISO CD 13584:

- cturing libraries of assembled parts (level 2; and level 3; libraries);
- description of the parts themselves;
- descriptions of the functional models that may refer to some family of parts;
- description of tables, program libraries and documents that may refer to some family of parts;

(NOTE: The terms "Level 2", "Level 3" and "functional model" are defined in ISO CD 13584-10. The terms "tables", "program libraries" and "documents" are used in ISO CD 13584-24.)

- **ISO/DIS 13584-101 Geometrical view exchange protocol by parametric program**

This part of ISO 13584 specifies a particular representation category, called basic_geometry . This representation category captures the generic concepts of the shape of a part. It may be associated with any of the items defined in a parts library. This part of ISO 13584 also defines how representations that belong to this representation category may be exchanged within a library exchange context by means of FORTRAN programs compliant with ISO 13584-31.
The following are **within** the scope of this part ISO 13584 :

- The definition of one particular representation category, called basic_geometry, and the mechanisms that shall be used to reference it;
- The properties that shall be used to characterize a particular representation within the basic_geometry representation category;
- The exchange format to be used for the library external files that describe the basic_geometry representations of classes of items described in a parts library by means of Fortran programs based on the application programming interface specified in ISO 13584-31;
- The implementation resources that shall be available on any implementation that claims conformance to this part of ISO 13584;
- The standard data that shall be recognized by any implementation that claims conformance to this part of ISO 13584.

The following is **outside** the scope of this part of ISO 13584:

- The resource constructs allowed, forbidden or mandatory in a dictionary or library that references this part of ISO 13584 in its supported_vep attribute.

NOTES
1) Dictionary and library are defined in ISO 13584-24.
2) ISO 13584-101 is intended to be used together with another view exchange protocol that specifies an integrated information model for exchanging functional model class hierarchies.
3) VEP 24-2, documented in ISO 13584-24, is a view exchange protocol that specifies an integrated information model for exchanging functional model class hierarchies.

- **ISO/CD 13584-102 View exchange protocol by ISO 10303 conforming specification**

This part of ISO 13584 specifies:

- The resource constructs needed to identify the different representation categories that may be supplied as STEP AP compliant files.
- The implementation resources that shall be available on any implementation that claims conformance to this part of ISO 13584.
- The standard data that shall be recognized by any implimentation that claims conformance to this part of ISO 13584.

The following is **outside** the scope of this part of ISO 13584:

- The resource constructs allowed, forbidden or mandatory in the library delivery file that references the library external files compliant with this part of ISO 13584.
- Mechanisms for ensuring that the library management system (LMS) on either side of a data exchange contain all of the semantics required by the domain of an ISO 10303 Application Protocol.

(NOTE: ISO 13548-102 is intended to be used together with VEP 24-2 whose integrated information model is documented in ISO CD 13584-24)